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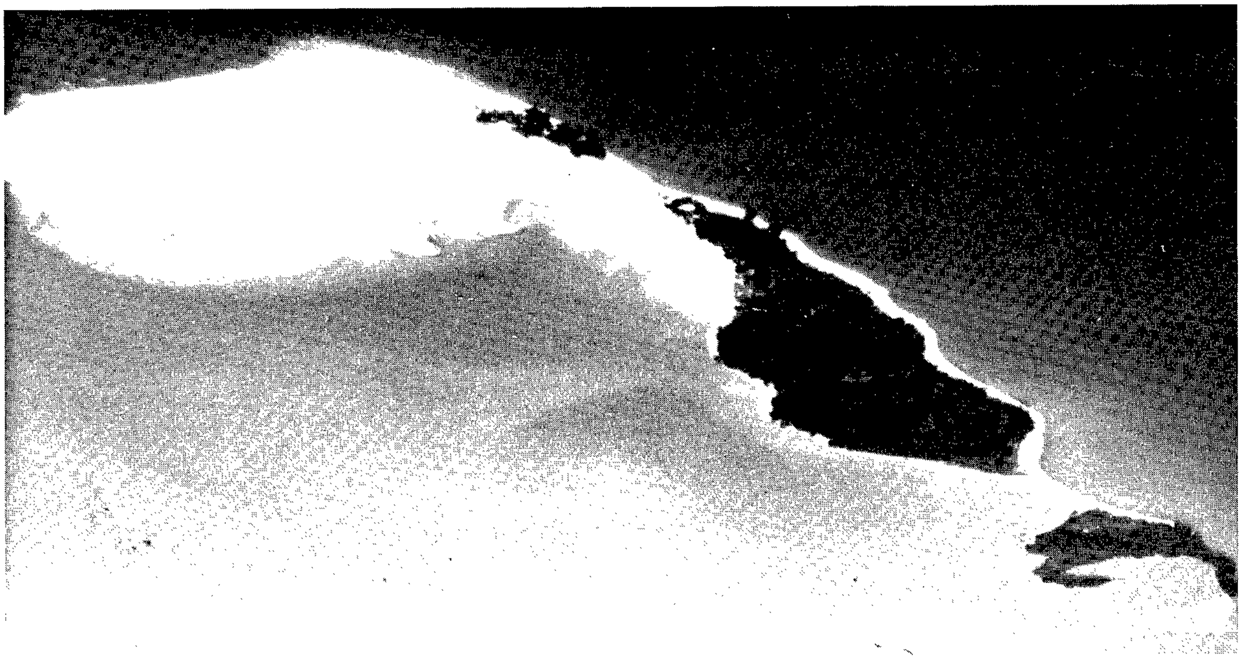

MITIGATION OPTIONS FOR FISH AND WILDLIFE RESOURCES AFFECTED BY PORT AND OTHER WATER-DEPENDENT DEVELOPMENTS IN TAMPA BAY, FLORIDA

Fish and Wildlife Service

U.S. Department of the Interior

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by

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PREFACE

This mitigation options report is part of a cooperative effort between the U.S. Fish and Wildlife Service and the Tampa Port Authority to develop an information base to assist in the identification of management and mitigation options that will allow development to proceed in an environmentally acceptable fashion. The purpose of this report was to evaluate past restoration projects and feasible mitigation options, identify potential restoration sites, and develop recommendations for management and mitigation in Tampa Bay.

The report evaluates projects in *Spartina*, mangrove, *Juncus*, eelgrass, and subtidal habitats and provides recommendations on the feasibility of restoration in these habitats. Potential sites where restoration was determined to be feasible are identified and evaluated. Management recommendations regarding the role and development of mitigation in management of Tampa Bay and the policy and legal framework to implement a mitigation program are discussed.

The first chapter describes the evaluation of past restoration projects that have been done in Tampa Bay. Chapter 2 discusses the feasibility of various types of restorations in Tampa Bay; Chapter 3 identifies and describes potential mitigation sites, and Chapter 4 discusses the role of, as well as the information needs for, mitigation planning and the legal and policy requirements to implement mitigation planning.

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CONVERSION TABLE

Metric to U.S. Customary

Multiply	By	To Obtain
millimeters (mm)	0.03937	inches
centimeters (cm)	0.3937	inches
meters (m)	3.281	feet
kilometers (km)	0.6214	miles
square meters (m^2)	10.76	square feet
square kilometers (km^2)	0.3861	square miles
hectares (ha)	2.471	acres
liters (l)	0.2642	gallons
cubic meters (m^3)	35.31	cubic feet
cubic meters	0.0008110	acre-feet
milligrams (mg)	0.00003527	ounces
grams (g)	0.03527	ounces
kilograms (kg)	2.205	pounds
metric tons (t)	2205.0	pounds
metric tons	1.102	short tons
kilocalories (kcal)	3.968	British thermal units
Celsius degrees	1.8(°C) + 32	Fahrenheit degrees

U.S. Customary to Metric

inches	25.40	millimeters
inches	2.54	centimeters
feet (ft)	0.3048	meters
fathoms	1.829	meters
miles (mi)	1.609	kilometers
nautical miles (nmi)	1.852	kilometers
square feet (ft^2)	0.0929	square meters
acres	0.4047	hectares
square miles (mi^2)	2.590	square kilometers
gallons (gal)	3.785	liters
cubic feet (ft^3)	0.02831	cubic meters
acre-feet	1233.0	cubic meters
ounces (oz)	28.35	grams
pounds (lb)	0.4536	kilograms
short tons (ton)	0.9072	metric tons
British thermal units (Btu)	0.2520	kilocalories
Fahrenheit degrees	0.5556(°F - 32)	Celsius degrees

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ACKNOWLEDGMENTS

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CHAPTER 1. EVALUATION OF PAST RESTORATION PROJECTS

1.1 BACKGROUND AND OBJECTIVES

The U.S. Fish and Wildlife Service (USFWS) is charged (through the Fish and Wildlife Coordination Act and Estuary Protection Act) with providing recommendations on mitigation of adverse impacts on fishes, wildlife, their habitats, and uses thereof from development projects undertaken by a Federal agency or requiring a Federal permit. The present study was initiated by the USFWS to provide an overview of options to mitigate unavoidable adverse environmental impacts of port development in the Tampa Bay area. The 10-month study consists of six major tasks:

1) review and evaluate past mitigation projects in the Tampa Bay area;
2) prepare a list of feasible mitigation options;
3) present Task 1 and 2 findings at a public workshop;
4) develop management and/or restoration recommendations;
5) identify and rank potential mitigation sites; and
6) present study findings at a final public workshop.

In development of the mitigation policy published in the 23 January 1981 Federal Register, the USFWS supported and adopted the definition of mitigation formulated by the President's Council on Environmental Quality in implementing regulations of the National Environmental Policy Act (NEPA). Mitigation is defined as:

1) avoiding an impact by not taking a certain action or parts of an action;
2) minimizing impacts by limiting the degree or magnitude of action and its implementation;
3) rectifying an impact by repairing, rehabilitating, or restoring the affected environment;
4) reducing or eliminating an impact over time by preservation and maintenance operations during the life of the action; and
5) compensating for an impact by replacing or providing substitute resources or environments (USFWS 1981).

The general statement of the policy is that the USFWS will "seek to mitigate losses of fish, wildlife, their habitats, and uses thereof from land and water developments." This is to be accomplished through "early involvement in land and water development planning activities in advance of proposals for specific projects or during the early planning and design stage of specific projects" (USFWS 1981).

Auble et al. (1985), in a report on a workshop in which mitigation options to port development in Tampa Bay were suggested, discussed two classes of mitigation options: those designed to avoid, minimize, rectify, or reduce the adverse impacts of development, and those designed to compensate for unavoidable impacts. Most of the first class of mitigation options fall under the heading of "good management practices" (Table 1). This document discusses the second class of mitigation options--those involving compensation for impacts where there is loss of habitat. However, implementation of management practices designed to reduce or avoid further impacts on Tampa Bay by port and other types of development are recommended before allowing development requiring compensation. These management practices are also an important part of any program developed to improve water

Table 1. Mitigation options to avoid, reduce, rectify, or minimize the effects of important impacts from port development (adapted from Auble et al. 1985).

Impact(s)	Mitigation option(s)
Nutrient (ammonia) release from disruption of sediment	None identified for impacts related to port developement
Siltation and turbidity	Upland or confined disposal[a] Protection of disposal areas (e.g., riprap)[a] New dredging technology (onboard computers)[a] Turbidity curtains and flocculents[a] No overflow from hopper dredges[a] Closed clamshell and barge
Other chemical release	Same mitigation options as for siltation and turbidity[a]
Change in circulation and salinity	Circulation cuts[a] Removing dikes and unblocking mosquito control ditches Removing silt along Big Bend channel
Loss of emergent wetland (mangrove and *Spartina alterniflora*)	No dredging, disposing, or filling in marshes[a] Bridging over marshes for dock construction[a] Enhancement of existing degraded marshes
Loss of nearshore subtidal habitat including seagrass	No dredging, disposing, or filling in shallow subtidal zone[a] Planting seagrass in subtidal areas currently without seagrass Protecting seagrass beds from excessive wave action[a]

[a]These options should be considered as good management practices.

quality and wetlands habitat within Tampa Bay.

1.2 TECHNICAL APPROACH

Ten past mitigation or restoration projects were selected for review and evaluation. Each project was evaluated by compiling pertinent historical data and by conducting an on-site inspection.

1.2.1 Selection of Past Projects

Projects were selected so as to maximize:

1) the range of habitat types included;
2) mitigation options for consideration;

3) spatial coverage of projects in Tampa Bay;
4) relevance to the Tampa Port Authority;
5) the amount of historical data available; and
6) the range and size of projects.

Projects suggested for consideration were obtained from discussions and meetings with staff from the USFWS, Tampa Port Authority (TPA), National Marine Fisheries Service (NMFS), Florida Department of Environmental Regulation (FDER), U.S. Army Corps of Engineers (USACE), Florida Department of Transportation (FDOT), and Florida Department of Natural Resources (FDNR).

1.2.2 Data Identification and Acquisition

Telephone interviews and meetings were held with local, State, and Federal agencies and other individuals or organizations having historical information on each project selected (Table 2). Data collected included a description of the project and mitigation action; photographs or maps of the site prior to, during, and after restoration; the mitigation plan; monitoring data; biological assessments; agency permit evaluations; name of contractor, firm, or person implementing the project; cost of the project; and any information available on public acceptance. Following collection and review of this information, additional written requests and telephone calls were made to attempt to obtain any pertinent data missing from each project's history.

To identify all available published and other unpublished scientific literature on habitat restoration, a computer search of several major data bases was implemented. Pertinent documents or publications were then obtained from their authors, or from agencies or academic institutions.

1.2.3 Field Investigations

Before the sites were visited, available information concerning access, availability, ownership, past physical characteristics (i.e., water depth, area, substrate type), and biology [i.e., habitat type(s), plant species composition, density, associated communities] was compiled. Aerial photographs were reviewed from the period 1946 to 1982 for each site in order to understand past physical or structural alterations and possible natural wetlands changes in or near each site. A field data log, including a site map, background information sheets, and a field data sheet (Figure 1) for each project, was then assembled prior to the field surveys.

Two Continental Shelf Associates, Inc. (CSA) scientists and a USFWS observer conducted the site investigations on 27, 28, and 29 November 1984. The field team used both land vehicles and, where appropriate, a 23-ft boat to assess the sites.

At each site, the field team first walked over the entire project area and took black-and-white photographs and color slides to document physical conditions, species composition and density, soil and sediment types, on-site land use, and fish and wildlife utilization. Where historical photographs were available, we attempted to repeat photography in similar locations. Photographic locations were recorded on the site map and indexed by number on the field data sheet (Figure 1). The major focus of the surveys was on wetland changes that have occurred since the completion of each project. Whenever possible, a map of existing vegetational zones was constructed. Estimates of plant density and/or percent cover of replanted vegetation were made within a 1 m^2 quadrat positioned along transects passing through the planting areas. The distance between quadrat samples and the number of sampling transects established varied, depending upon project size. Locations of all transects and sampling data were recorded in the field data log for each site.

Observations of organisms observed on the site or caught in beach seines were noted. Additional data recorded at each site are specified in Figure 1. Immediately upon returning from the field, the scientists reviewed the field data log to ensure that all required information

Table 2. List of contacts made for source information on mitigation/restoration projects in Tampa Bay.

Agency	Location	Contact(s)
Audubon Society	Tampa, FL	Rich Paul
Florida Department of Environmental Regulation	Tampa, FL	Bill Kutash Allan Hooker Larry Devroe
	Tallahassee, FL	Fred Calder Andy Feinstein Suzanne Walker Joe Ryan Scott McClelland Mark Latch
Florida Department of Natural Resources, Marine Research Laboratory	St. Petersburg, FL	Ken Haddad Alan Huff Karen Steidinger Mike Durako Barbara Harris
Florida Department of Transportation	Bartow, FL	Wendy Geisy
Hillsborough County	Tampa, FL	Rick Wilkins
Mangrove Systems, Inc.	Tampa, FL	Robin Lewis Steve Lumbert
Martel Laboratories, Inc.	St. Petersburg, FL	Tom Kunneke Keith Patterson
National Marine Fisheries Service	Panama City, FL	Ed Kepner David Nixon
	St. Petersburg, FL	Andy Major
Southwest Florida Water Management District	Tampa, FL	William Courser
Tampa Bay Regional Planning Council	St. Petersburg, FL	Mike McKinley Doug Robison David Griffith
Tampa Marine Institute	St. Petersburg, FL	Bill Hoffman
Tampa Port Authority	Tampa, FL	Bill Fehring
U.S. Army Corps of Engineers	Tampa, FL	Joe Bachelor
	Jacksonville, FL	Lloyd Saunders

(continued)

Table 2. (Concluded).

Agency	Location	Contact(s)
U.S. Fish and Wildlife Service	Atlanta, GA	Jim Brown
	Panama City, FL	Lorna Sicarello Jim Barkuloo
	Slidell, LA	Jim Johnston Larry Shanks Millicent Quammen
	Vero Beach, FL	Joe Carroll Arnold Banner Bob Turner
Gardinier Phosphates, Inc.	Tampa, FL	Robert Melright
Frandorson Properties	Apollo Beach, FL	Thomas Corr
Sundown Construction Company	St. Petersburg, FL	Robert Wray
City of St. Petersburg Engineering Department	St. Petersburg, FL	Kirk Pierce

had been obtained and was properly recorded.

1.3 RESULTS AND DISCUSSION

1.3.1 Overview of Mitigation Actions in Tampa Bay

Over the past four decades, significant declines in wetland habitat have occurred in Tampa Bay, primarily as a result of dredge-and-fill activities prior to 1970 and a decline in water quality associated with population growth in the Tampa Bay region (Simon 1974; Continental Shelf Associates, Inc. 1983). The status and trends of habitats in the Tampa Bay area were discussed during the U.S. Fish and Wildlife Service (USFWS)-Tampa Port Authority (TPA) Mitigation Workshop held 25-27 September 1983 (Auble et al. 1985). Historical losses of wetlands in Tampa Bay make it imperative that further wetland losses be reduced or avoided in the planning stages and that any unavoidable wetland losses associated with future projects be accompanied by well-designed measures to compensate for those losses.

Major mitigation and restoration projects in Tampa Bay have been conducted since the early 1970's as a result of increased involvement by the USACE and FDER in the process of permitting potential pollution sources. Historically, wetland losses have occurred through lack or weak interpretation of laws defining the extent of State and Federal jurisdiction in wetlands areas (see Section 1.3.9). In Florida, the recently passed Warren S. Hendersen Wetlands Protection Act of 1984 is an attempt by the legislature to strengthen wetlands protection by defining extent of State waters and the jurisdiction of FDER within those waters.

Many early mitigation requirements were associated with after-the-fact permit authorization and enforcement. Recent projects have involved incorporation of a mitigation plan as part of the permit.

Date: Site:
Time: Location:
Personnel: Mitigation Type:

Area: Estimate from aerials (acreage/plant types)

Ground-truthing estimate revision (acreage/plant type)

Land-Use:
______ Spoil Island
______ Industrial
______ Commercial
______ Residential
______ Recreational
______ Sanctuary/Refuge

Plant Species Composition & Density:
Species Density (m^2)

Fishes & Wildlife:
Species Foraging Nesting Other

Soil & Sediment Types:
Location
______ Rubble
______ Coarse Sand
______ Fine Sand
______ Silt/Clay
______ Organic Material

Elevation/Erosion:
Location Slope (Ratio) Erosion (observation)

Water Quality:
Location Water Clarity Flushing Characteristics

Depth Ranges:
Location (Keyed to map) Depth (soundings alongshore)

General Observations:

Possible Reasons for Success/Failure:

Photo Index:
Roll No. Photo No. Map Location Subject

Project Manager Review ______________ Date ________

Figure 1. Tampa Bay mitigation project field data sheet (task 1).

The types of wetland habitat in which restoration or creation has been attempted include mangrove islands, mangrove shorelines, marsh islands, marsh shorelines, tidal creek marshes, high marshes, and subtidal sand bottom. Most permits that have included mitigation actions have been applied for by the TPA, private industry, waterfront developers, and the FDOT.

The 10 projects selected for review are listed in Table 3 along with information on location, permittee, description of work, present habitat type, mitigation action, and project size. Locations of the projects are shown in Figure 2. Of the 10 selected projects, three were for restoration through enforcement consent order for unpermitted activities; three were mitigation plans incorporated into project permits; one was for controlling shoreline erosion of a canal; two were for vegetating spoil islands created by dredge-and-fill permits given to the TPA; and one was for a subtidal sand habitat created by filling an old channel for safety and recreational purposes.

1.3.2 Palm River, Tampa By-Pass Canal

a. Description. In 1979, the Southwest Florida Water Management District (SWFWMD) attempted a trial program to control erosion by using estuarine vegetation along a severely eroded portion of the Palm River (Figure 3). The Palm River, or Tampa By-Pass Canal, is tidally connected to Hillsborough Bay through McKay Bay (Figure 2). Comparison of 1964 and 1974 aerial photographs in a 1977 survey (Mangrove Systems, Inc. 1977) revealed a 2,415 m^2 loss of vegetative cover to erosion. The greatest erosion resulted from the removal of intertidal vegetation during a cleanup of dredged material within this time period. Terrestrial vegetation growing on top of the eroding escarpment shaded the intertidal zone and relatively minor wave action from passing boats caused erosion of the unvegetated shoreline (Mangrove Systems, Inc. 1977).

b. Mitigation/restoration plan. In June 1979, 60 m along the Palm River shoreline was cleared and graded to a 15:1

(H:V) slope extending waterward below mean sea level (MSL) and planted with Paspalum vaginatum (salt joint grass), Spartina alterniflora (cordgrass), and Argentine Bahia sod following the planting outline shown in Table 4. Interested residents living along the SWFWMD easement planted an undetermined number of Rhizophora mangle, Avicennia germinans, and Laguncularia racemosa (red, black, and white mangroves, respectively) at elevations below that of the other plantings.

Total cost of the project was $27,220, including $16,200 for SWFWMD staff charges (permitting, management, etc.); $7,400 for construction and installation of plant materials; $2,500 for studies and monitoring by Mangrove Systems, Inc.; and $1,120 for repairs due to upland erosion. The cost of construction and installation ($7,400 or approximately $123/m) compares favorably with the installation costs of a nearby sand/cement revetment (approximately $330/m) (Courser and Lewis 1980).

c. Monitoring data. The site was revisited on 8 January 1980 (Mangrove Systems, Inc. 1980), approximately 6 months after installation of the plants. Paspalum vaginatum had spread and coalesced to give 100% coverage of the planting area except for one erosion gully area, which was repaired. Only about 200 of the original 1,050 S. alterniflora plants were evident. Reasons for the poor performance of the S. alterniflora were reported to include the late planting time (June rather than April), the small size of the plants installed, unrestricted public access to the site (which caused further stress to the plants), and debris floating on shore and knocking plants over (Courser and Lewis 1980). Small mangroves were reported thriving at the 6-month inspection.

Recommended maintenance of the area included (Mangrove Systems, Inc. 1980):

1) mowing the P. vaginatum to a height of 0.5 m every 6 months to exclude re-invasion of exotic woody species;
2) removing at 6-month intervals the floating debris which becomes stranded at the site; and
3) controlling public access to prevent damage to the plantings.

d. Field assessment. Continental Shelf Associates, Inc. (CSA) scientists visited the Palm River/Tampa By-Pass Canal on 27 November 1984, 5.5 years after planting, and it was obvious that the site had not been maintained as proposed in 1980. The area east of the project had eroded to form an escarpment and had evidence of dead S. alterniflora plants (Figures 4 and 5). The shoreline within the project area had a 1- to 6-ft wide band of S. alterniflora, a single R. mangle, and 10 A. germinans (Figure 6). The P. vaginatum planting had been almost completely covered by an unidentified terrestrial vine. A resident had cleared a planting area for water access and boat launching.

Fishes and wildlife observed during the assessment included Eucinostomus argenteus (spot-fin mojarras) in the Palm River, Geukensia demissa (ribbed mussel) attached to the base of the S. alterniflora (Figure 7), and Littorina anqulifera (marsh periwinkle) on the stems. Many Uca spp. (fiddler crab) holes were observed in the S. alterniflora band.

e. Evaluation. The primary goals of this shoreline restoration project, to control erosion and stabilize the shoreline, were only partially achieved. Comparison of the planting site with areas to the east (Figures 4 and 6) indicates that where P. vaginatum and S. alterniflora plantings survived within the planting site, the efforts have retarded erosion and subsidence of the canal bank (Figure 8). Apparently, minimal changes in shoreline contours have occurred since the final monitoring survey in 1980. The 5- to 6-ft band of S. alterniflora is providing habitat for dense populations of Geukensia demissa, Littorina anqulifera, and Uca spp.

The lack of plant survival at the eastern end can be attributed to upland runoff; subsidence of the bank, which has caused plant burial; erosion and scouring of the planting from boat wakes; and competition with terrestrial vegetation.

Table 3. Selected Tampa Bay mitigation/restoration projects.

Project location	Permittee	Project description
Hillsborough County, Palm River, Tampa By-Pass Canal	Southwest Florida Water Management District	Filling wetlands for upland development
Hillsborough County, Archie Creek	Gardinier, Inc.	Construct a pollution control system filling 1.5 ha of tidal marsh
Hillsborough County, CDA-D (Fantasy Island) and Spoil Island 2-D	TPA	Mitigation for construction of shrimp boat docks
Hillsborough County, Sunken Island	National Audubon Society/USACE	Improvement initiated by National Audubon Society
Hillsborough County, Wolf Creek/Apollo Beach	Frandorson Properties	Enforcement action for unpermitted dredging
Manatee County, Branches Hammock	FDOT	Construct roadway over needlerush (*Juncus roemarianus*) marsh filling 0.6 ha and disturb by construction techniques 2.3 ha
Pinellas County, Feather Cove	Radice Corporation	Fill in wetlands for residential development; USACE Permit No. 82U-1047
Pinellas County, Weedon Island/Papy's Bayou	Harbor Island Development, W. Langston Holland	Fill wetlands for uplands development; USACE Application No. SAJSP73-0080
Pinellas County, Placido Bayou	Robert D. Wray	Construct borrow pit in wetlands; USACE Permit No. 82-0357
Pinellas County, Lassing Park	City of St. Petersburg	Filling of old borrow pit and channel

Habitat type	Mitigation action	Project size
Marsh, mangrove/shore	Restore river bank by lowering elevation of upland	0.012 ha of *Spartina alterniflora*
Marsh/shore	Restore tidal marsh with *S. alterniflora*	1.82 ha
Mangrove, marsh/island	Construct island using dredge material, stabilize existing island	0.5 ha planted in black and white mangroves, 1.6 ha in *S. alterniflora*
Marsh/island	Construct island using dredge material, stabilize existing island	1.64 ha planted in *S. alterniflora*
Euryhaline/tidal creeks and marsh shore	Lower elevation and plant with red mangrove (*Rhizophora mangle*)	25,000 mangrove seedlings over a 1.6-ha area
Euryhaline/tidal creeks	Restore altered tidal creeks	Salt marsh restoration project resulting in the restoration of 2.3 ha of needlerush marsh
Marsh, mangrove/shore	Construct marsh along man-created shoreline	3.1 ha of *S. alterniflora* planted
Marsh/shore	Construct marsh by lowering the elevation of uplands	10 ha
Marsh, mangrove/shore	Construct marsh by removing open, undiked spoil or lowering elevation of uplands	1 ha of mitigation proposed
Subtidal sand bottom adjacent to seagrass beds	Filling of borrow pits/ seagrass revegetation	3.9-ha fill area

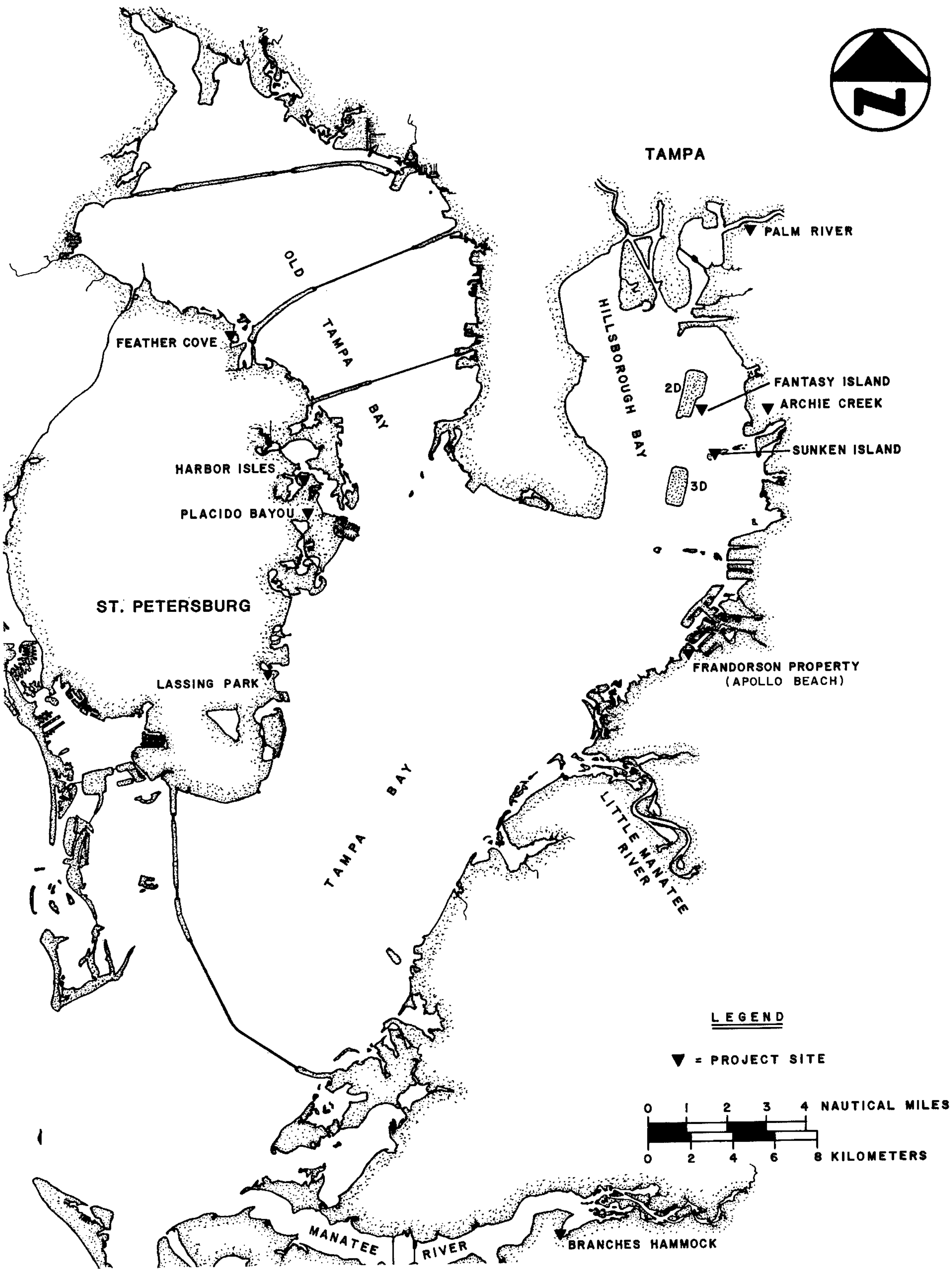


Figure 2. Geographic locations of selected past projects.

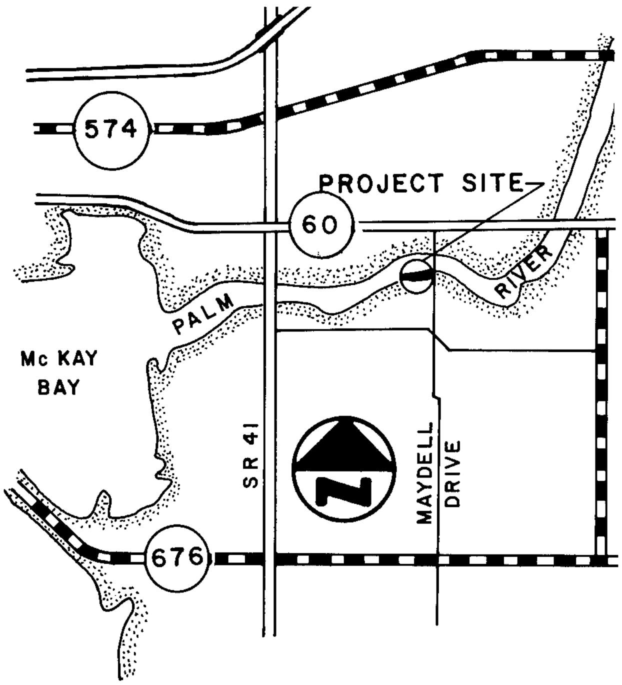


Figure 3. Location of the Palm River site in relation to McKay Bay (from Mangrove Systems, Inc. 1977).

Channelization and maintenance dredging have led to the loss of wetlands habitat. Had maintenance been implemented, as recommended by Mangrove Systems, Inc. (1980), the resource value, longevity, and plant survival of the project would have been increased.

Use of riprap to dissipate the wave energy and filter cloth to stabilize the planting and prevent erosion could have increased the life-span and effectiveness of the project. Initially public acceptance of the project was good, as evidenced by the willingness of some residents to plant mangroves; however, recently one resident cleared vegetation to provide access to the river.

Although this project was not a mitigation action, it should provide useful data to regulatory agencies when considering a mitigation plan for shoreline restoration in similar canal systems and moderate to high energy shorelines in Tampa Bay.

1.3.3 Archie Creek

a. Description. A 1.82-ha *S. alterniflora* marsh was restored from upland to mitigate for loss of a *S. alterniflora* marsh during construction

Table 4. Planting details for Palm River erosion control project (from Courser and Lewis 1980).

Plant	No. planted	Planting elevation (MSL)	Planting pattern
Spartina alterniflora	1,050	-0.12 to +0.43 m	Plant and root plug installed/ 0.3-m centers, fertilized with 1 oz/plant 18-6-12 ($N:P_2O_5:K_2O$) slow-release fertilizer
Paspalum vaginatum	350 - 400	+0.46 to +1.07 m	Plant and root plug installed/ 0.9-m centers, fertilized with 1 oz/plant 18-6-12 ($N:P_2O_5:K_2O$) slow-release fertilizer
Bahia sod	4,400 ft^2	above +1.07 m	Continuous sod

Figure 4. Shoreline of Palm River east of restoration area.

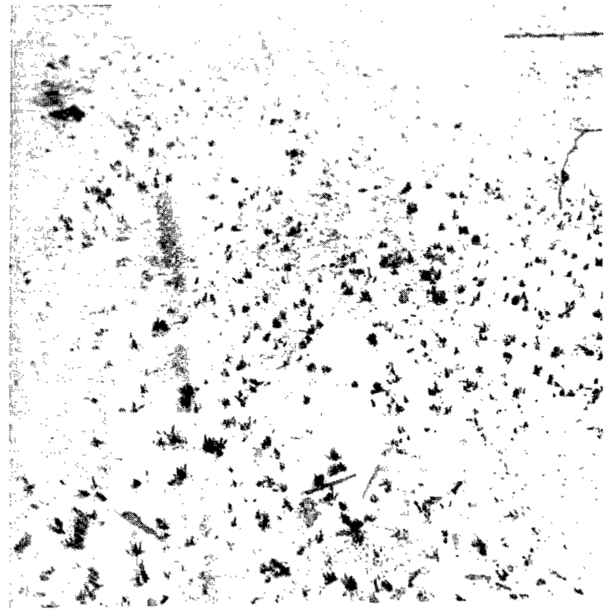


Figure 5. Remnants of Spartina alterniflora plantings at Palm River.

Figure 6. Restored shoreline at Palm River with band of Spartina alterniflora in foreground, and Paspalum vaginatum and upland plants in background.

Figure 7. Ribbed mussels (Geukensia demissa) attached to base of Spartina alterniflora.

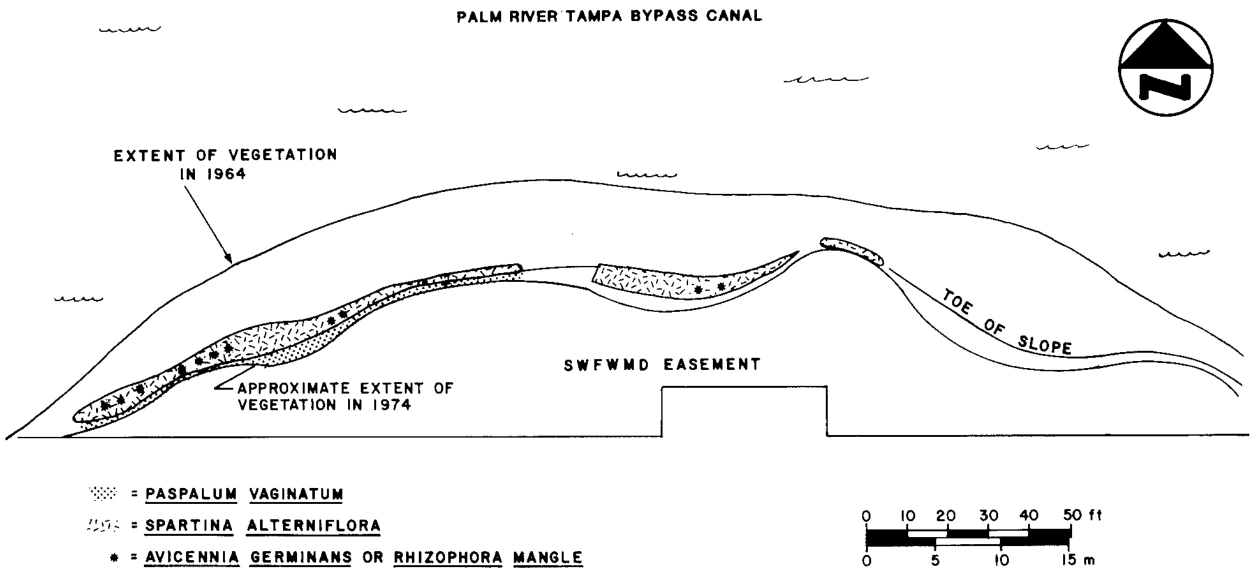


Figure 8. The Palm River restoration site showing vegetation as mapped during the 26 November 1984 field assessment.

of a 96-ha holding pond for accumulated storm water (Figure 2). This project was initiated and constructed in 1977 by Gardinier, Inc. Construction of the pond, located east of the Gardinier plant facilities, resulted in filling 1.5 ha of tidal marsh system associated with Archie Creek (Figure 9).

b. Mitigation/restoration plan. The mitigation plan was prepared by Henley Environmental Services, Inc. (1977) in response to requirements by State and Federal regulatory agencies. The plan included construction of a 1.82-ha marsh in areas designated C and C1 (Figure 9).

The areas were prepared during the construction of the pond system early in 1978 by Gardinier, Inc. Mangrove Systems, Inc. planted the area with *S. alterniflora* for a cost of $14,000 in April 1978 using the following methods (Mangrove Systems, Inc. 1978a):

> Plugs of *S. alterniflora* were removed from an existing tidal marsh on the west side of U.S. Highway 41 immediately north of the Gardinier, Inc. plant facility, on Gardinier, Inc. property. The plugs were 4 to 5 inches in diameter and were removed using standard post-hole diggers. The plugs were transported intact in shallow plastic trays and placed into holes at 3-ft intervals in the planting area. One ounce of Osmocote® Slow-Release (3 to 4 months) 14-14-14 ($N:P_2O_5:K_2O$) fertilizer was side dressed at each planting site after all the planting was completed.

c. Monitoring data. Mangrove Systems, Inc. conducted monitoring surveys at the completion of the planting (25 June 1978); 6 months after planting; and 1 year (1 May 1979) after planting. Initially, 2,127 plugs of *S. alterniflora* were planted. In the 6-month report, 75% survival of the plugs was indicated; losses were attributed to burial due to erosion of the unvegetated pond wall and to unknown causes in lower, more frequently inundated areas. In the 1-year report, the number of culms had increased on average from $5/m^2$ to $218/m^2$ in the areas of highest survival. Overall survival rate of the planted culms was 75%. In addition, *A. germinans* seeds had floated into the area and germinated (Mangrove Systems, Inc. 1978b).

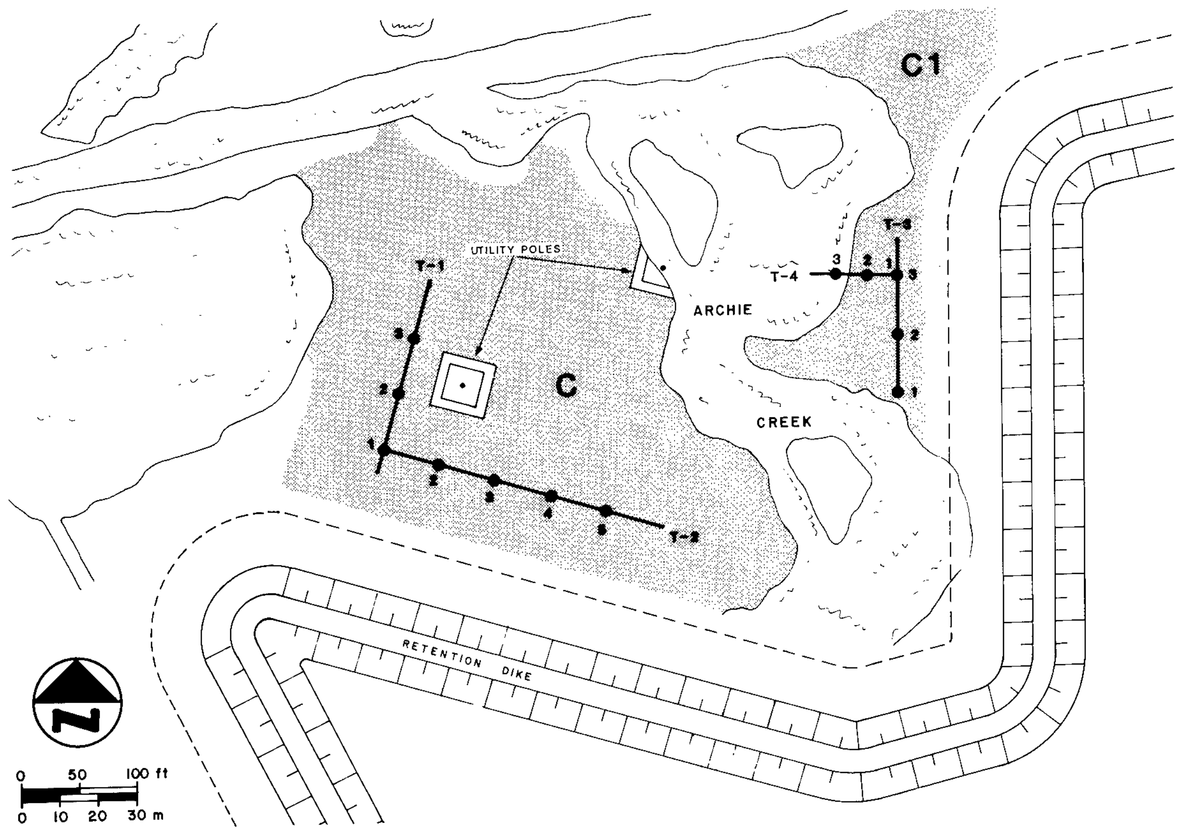


Figure 9. Transects (T-1 through T-4) and sampling stations for the 26 November 1984 field assessment of the Archie Creek site (from site plan by Gardinier, Inc. January 1978).

d. Field assessment. Continental Shelf Associates, Inc. (CSA) scientists visited the Archie Creek site on 26 November 1984, approximately 6.5 years after the initial planting. The site appeared to be a naturally functioning marsh. The area had several tidally inundated creeks and mudflat areas with slightly higher surrounding areas of S. alterniflora (Figure 10). A few small A. germinans seedlings had invaded an area of sandy soil, approximately 6 m wide, surrounding the project. This area consists of sand as opposed to the soft anaerobic mud of the remainder of the marsh. Erosion mentioned in the monitoring reports could have produced this perimeter of sandy soil. A few small tree islands, two of which were constructed to support telephone poles,

Figure 10. View looking north at natural Spartina alterniflora marsh at the Archie Creek restoration site.

existed within the marsh. The marsh was surrounded by a hedge of Baccharis halmifolia (salt bush) and A. germinans on the sides next to the holding pond dike.

Plant species composition and density were assessed (Figure 11) at intervals along four transects (Figure 9). The average density of S. alterniflora was approximately 230 culms/m^2 (Table 5). Invasion of A. germinans and P. vaginatum in the area surrounding the marsh was observed along Transects 2 and 3. Wildlife observed during the field assessment are listed in Table 6.

e. Evaluation. The planting project at Archie Creek represents a successful attempt to plant S. alterniflora in this area.

Public interest was not a consideration in this project due to lack of access to the site. Officials at Gardinier, Inc. voiced an interest in continued long-term success of the project.

1.3.4 Fantasy Island (CDA-D) and Spoil Island 2-D

a. Description. Wetlands vegetation was planted on Fantasy Island (CDA-D) and Spoil Island 2-D (Figure 2) by the TPA to

Figure 11. Field team making density estimates along Transect 1, Archie Creek site.

Table 5. Vegetation within the 1-m^2 quadrats along each transect line at Archie Creek.

	Transect[a]			
Station	1	2	3	4
1	377 Sa	377 Sa	200 Sa 1 Ag	200 Sa 8 Ds
2	88 Sa	239 Sa 10 Ds 2 Ag	184 Sa 8 Ds	120 Sa
3	115 Sa	342 Sa	200 Sa 8 Ds	200 Sa
4		312 Sa		
5		232 Sa		

[a]Sa = Spartina alterniflora (no. of culms)
Ag = Avicennia germinans (no. of individuals)
Ds = Distichlis spicata (% cover).

Table 6. Organisms observed at Archie Creek during the 26 November 1984 field assessment.

Invertebrates

Melampus bidentatus (common marsh snail)
Littorina irrorata (marsh periwinkle)
Geukensia demissa (ribbed mussel)
Uca spp. (fiddler crabs)

Vertebrates

Charadrius vociferus (Killdeer)
Agelaius phoeniceus (Red-winged Blackbird)
Limnodromus griseus (Short-billed Dowitcher)

mitigate loss of 2.1 ha of productive intertidal habitat and a fringe of A. germinans and L. racemosa (FDER Biological and Water Quality Assessment, 1978) incurred during the construction of a shrimp dock facility in 1979. Federal and State regulatory agencies required 1:1 (destroyed:created) wetland mitigation.

b. Mitigation/restoration plan. Fantasy Island (CDA-D) (Figure 12) and Spoil Island 2-D, located 2.5 km south of Pendola Point in Hillsborough Bay, were created with dredged material in 1978. Fantasy Island, approximately 8.1 ha in area, is protected from severe wave action by Spoil Island 2-D, approximately 240 ha in area, to the west. Both the small island and the dikes of Spoil Island 2-D are composed predominantly of shell and sand.

Fantasy Island was planted in 1979 with 0.3 to 1.9 m high transplants of A. germinans and L. racemosa (Figure 13) by the Tampa Marine Institute. The mangroves were removed by shovel and the root balls (root and substrate complex) were wrapped in burlap. Transplants were taken at random from the source area and transplanted via boat to Fantasy Island (Hoffman and Rodgers 1981). The mangrove planting was done on 2-m centers ranging from 0.6 to 0.9 m above mean low water (MLW) during January to June 1979. A total of 1,513 mangroves (63% A. germinans and 37% L. racemosa) were placed in a 0.52 ha area. The approximate cost of the mangrove planting was \$11,459/ha or \$3.92/transplant.

Fantasy Island and most of the eastern shoreline of Spoil Island 2-D were

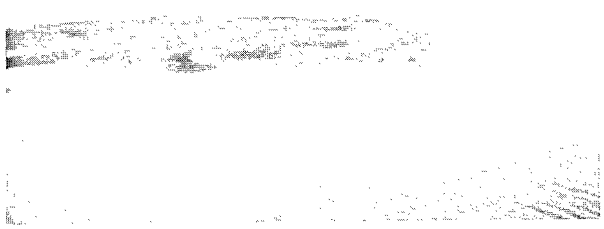


Figure 12 View of southern end of Fantasy Island mangrove revegetation project, May 1979.

planted with plugs of S. alterniflora in 1981 by Environmental Wetland Gardens, Inc. (Figure 14). An approximate combined area of 1.6 ha on the islands was planted on 1-m centers with 10,000 plugs of S. alterniflora (3 culms/plug). The planting cost was \$0.31/plant or approximately \$2,000/ha.

c. Monitoring data. Hoffman and Rodgers (1981) reported 73.3% survival of

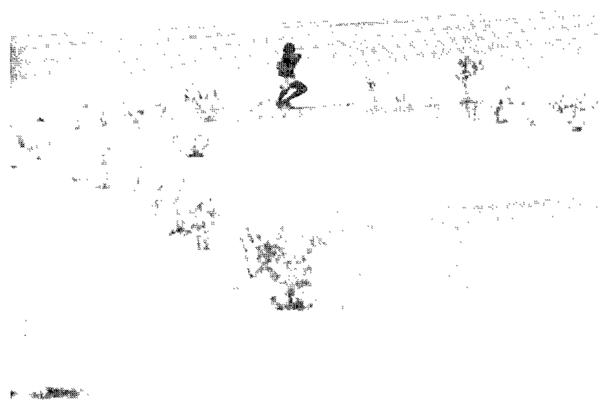


Figure 13. Fantasy Island, 31 August 1979, following mangrove revegetation.

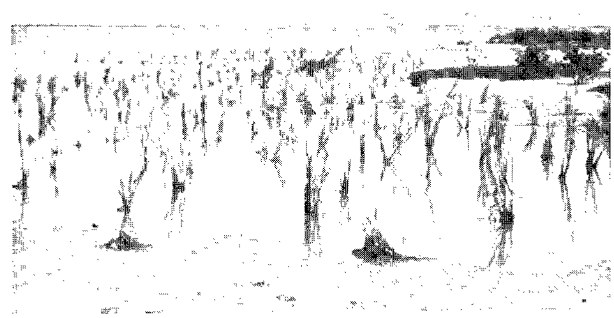


Figure 14. Fantasy Island Spartina alterniflora planting project, July 1981. Illustrates interior tidal basin where cordgrass is planted and tidal channel in background.

the A. germinans and L. racemosa after 13 months, with losses occurring mainly in the lower areas of the planting. Severe winter weather in the first years after transplanting shocked the plants, producing leaf-drop. Most of the plants recovered, however, and a few flowered in the first season. No formal monitoring program was conducted by the S. alterniflora planting contractor. The TPA staff has photographically monitored the S. alterniflora planting and has found that most of the transplants have been lost to erosion; however, the plantings on Fantasy Island and the northeast corner of Spoil Island 2-D have survived.

d. Field assessment. Continental Shelf Associates, Inc. (CSA) scientists visited Fantasy Island on 27 November 1984, approximately 5 years after the initial mangrove revegetation and 3.5 years after the S. alterniflora planting. The restored habitat area currently is characterized (Figure 15) by a central low marsh receiving tidal inundation from a small creek. The marsh is dominated by open sand with

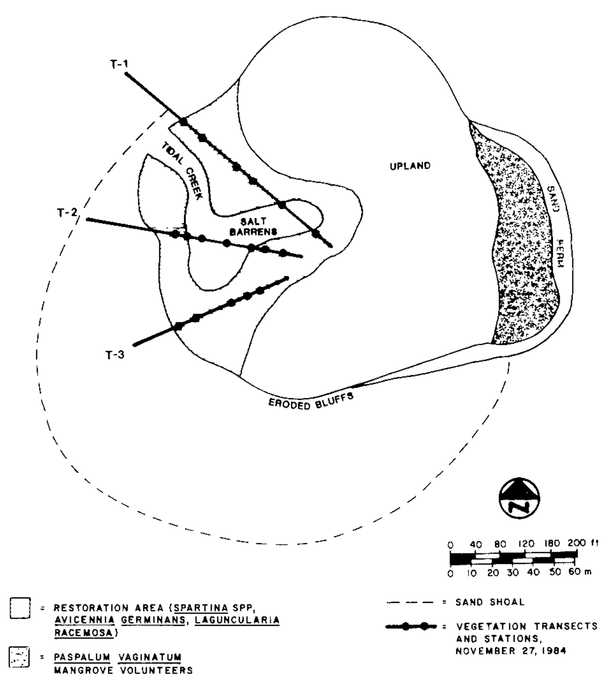


Figure 15. Diagram of the Fantasy Island site showing transects (T-1 through T-3) for the 27 November 1984 field assessment.

S. alterniflora, P. vaginatum, A. germinans, and L. racemosa (Figure 16). A high marsh surrounds this central depression and is dominated by P. vaginatum, Salicornia virginica, A. germinans, and L. racemosa (Figure 17). There is an upland/transitional zone characterized by scattered Baccharis halimifolia and Schinus terebenthifolius with a ground cover of P. vaginatum (Figure 18). Paspalum vaginatum has expanded throughout most of the restored area and, except for the open salt

Figure 16. Marsh area on Fantasy Island dominated by open salt barren, Paspalum vaginatum, and stunted rows of mangroves.

Figure 17. Southern edge of planting area on Fantasy Island dominated by black (Avicennia germinans) and red (Rhizophora mangle) mangroves and Paspalum vaginatum.

Figure 18. Transitional high marsh/upland area on Transect 1, dominated by Batis maritima, Paspalum vaginatum, and scattered Avicennia germinans and Laguncularia racemosa.

barrens, comprises 10% to 100% of the vegetation cover. Spartina alterniflora had coalesced in areas where initial transplants survived.

Plant species composition and percent cover were assessed at intervals along three transects (Figure 15, Table 7). Spartina alterniflora densities ranged from 45 to 200 culms/m^2 in the low marsh area. In the high marsh area surrounding the central low marsh (Figure 15), rows of A. germinans ranging in height from 15 cm to 1.2 m were observed. At the south end of the island severe erosion has removed several mangroves (Figure 19). Freeze damage was apparent along the southern edge of the restored area. Substrate in the marsh and on the beach was medium to coarse, clean sand. Large numbers of Cyprinodon variegatus (sheepshead minnow) were collected in the interior marsh, and juvenile and adult Mugil curema (silver mullet) and Anchoa mitchilli (bay anchovy) were collected along the beach. No birds were observed foraging, nor did the uplands appear to have been used as a rookery. Patton and Hanners (1984) found that, after their creation, these two islands almost immediately became nesting areas for the Laughing Gull (Larus atricilla). In 1982, Fantasy Island supported 15,300 pairs of laughing gulls, making it the largest colony site in Tampa Bay. In 1981, observations of colonies of Gull-billed Terns (Gelochelidon nilotica), Least Terns (Sterna antillarum), and Black Skimmers (Rynchops niger) were made (Patton and Hanners 1984).

e. Evaluation. This restoration project was not entirely successful in that a wetland habitat of comparable size to that which was lost was not created. The survival of transplanted mangroves was at best 50% to 60%. Factors that may account for the high mortality among transplants include freeze damage and exposure, improper planting elevations, erosion at the south end of the islands, physiological stress caused by transplanting, and inadequate tidal flushing. A review of aerial imagery from 1979 and 1982 reveals that Fantasy Island is eroding on the southern shoreline and possibly expanding into a subtidal area to the south. The slow growth of the existing mangroves and the lack of natural mangrove recruitment probably reflects the infrequent transport of seeds into this area. A berm that has developed along the high beach prevents tidal inundation (Figure 15), and the only access for seeds is by way of the small tidal rivulet. Seed availability and transport could vary seasonally, however. Poor flushing may also explain the lack of attached bivalves or gastropods in the marsh. It is doubtful that a mature mangrove community will eventually develop without some structural modification to this site. Greater utilization of S. alterniflora, increased tidal flushing, enhanced seed access and entrapment ability, and stabilization of the south shoreline could substantially increase the productivity and diversity of this habitat. Provided that a seed source is available, areas for mangrove restoration would be better vegetated first with S. alterniflora, structurally modified to provide tidal flushing for seed entrapment, then left to recruit mangroves naturally (as was the case at Sunken Island). Both the Fantasy Island and Sunken Island projects demonstrate that dredge spoil can effectively be used to create productive

Table 7. Vegetation within the 1-m^2 quadrats along each transect line at Fantasy Island.

Station	Transect[a] 1	2	3
1	45 Sa	156 Sa	52 Sa
2	200 Sa 5 Ag (0.6 m hgt) 1 Lr	100 Sa 25% Pv	100% Pv 6 Ag (1.2 m hgt)
3	100% Pv 5 Lr (15 cm hgt)	108 Sa 50% Pv	Os 1 Ag (0.3 m hgt)
4	100% Sv 5 Ag (15 cm hgt)	100% Pv 17 Ag (1.2 m hgt)	50% Pv 8 Ag (0.3 m hgt) 1 Bh
5	10% Sv 3 Ag (1.2 m hgt) 3 Lr (1.2 m hgt)	Os	100% Pv
6	Os	25% Pv	Bh
7	100% Pv	100% Pv 2 Ag (1.2 m hgt)	

[a]Lr = Laguncularia racemosa (no. of individuals)
Ag = Avicennia germinans (no. of individuals)
Sa = Spartina alterniflora (no. of culms)
Os = Open sandflat
Pv = Paspalum vaginatum (% coverage)
Sv = Salicornia virginica (% coverage)
Sp = Sesuvium portulacastrum (% coverage)
Bh = Baccharis halimifolia (presence).

Figure 19. Highly eroded shoreline along south side of Fantasy Island.

wetlands in Tampa Bay. However, subtidal habitat is destroyed in the process.

1.3.5 Sunken Island

a. Description. An extension of the dredge spoil island, Sunken Island, was proposed by the Tampa Marine Institute and the National Audubon Society. Sunken Island, located in Hillsborough Bay at the mouth of the Alafia River (Figure 2), is leased and managed as a bird sanctuary by the National Audubon Society (Figure 20). Spartina alterniflora was planted on a dredged-material extension of Sunken Island to stabilize the substrate, increase habitat diversity and provide

foraging areas for local shorebirds, and provide nesting habitat for Rallus longirostris (Clapper Rail) and Catoptrophorus semipalmatus (Willet). The planting was conducted by the Tampa Marine Institute.

b. Mitigation/restoration plan. The dredged material extension of Sunken Island was created in November 1977 in an "L"-shaped cove with a southwest exposure (Figures 20 and 21). The intertidal area of this cove was chosen for planting because of its low wave energy. The substrate was composed primarily of sand and silt.

The area was planted from 16 October 1978 to 13 March 1979 with 12-cm plugs of *S. alterniflora*, which were removed at approximately 1 plug/m^2 via posthole digger from existing marshes along the southern bank of the Alafia River and Whiskey Stump Key (approximately 5 km to the east). After the blades were clipped to 10 cm above the substrate, the intact plugs were transported by boat to the planting area. Plugs were planted on 1-m centers in rows 2 m apart between 0.2 and 0.9 m above MLW. A total of 7,261 plugs were placed in a 1.64-ha area. The cost was approximately $4,565/ha or $1.03/plug (Hoffman and Rodgers 1981).

c. Monitoring data. Hoffman and Rodgers (1981) reported 93.4% survival of the *S. alterniflora* plugs after 14 months. Losses were concentrated at the upper and lower tidal extremes of the planting. Spreading of the plugs had almost obscured the rows, and seed production had occurred (Hoffman and Rodgers 1981).

d. Field assessment. Continental Shelf Associates, Inc. (CSA) scientists visited Sunken Island on 27 November 1984

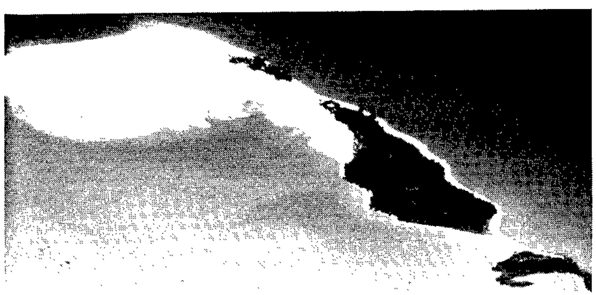


Figure 20. Aerial view (1977) of Sunken Island addition prior to restoration.

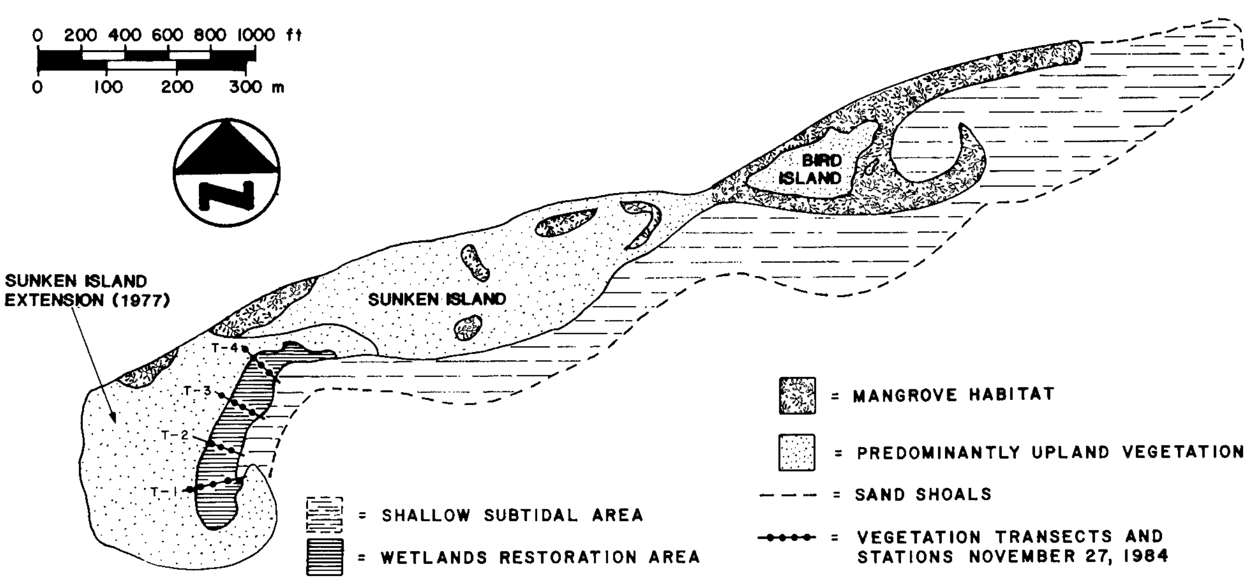


Figure 21. Diagram of the Sunken Island site showing transects (T-1 through T-4) for the 27 November 1984 field assessment.

at 1130 hours (approximately low tide), 6 years after planting. Overall, Sunken Island was the most diversified restoration project visited during this survey due to the combination of many different kinds of habitats found there (i.e., S. alterniflora marsh, mangroves, upland, open sand beach, shallow intertidal, and subtidal) (Figures 22, 23, and 24). The S. alterniflora plugs had coalesced into a marsh and R. mangle, A. germinans, and L. racemosa seedings had recruited and reached 0.5 to 1.5 m in height (Figure 22).

Figure 22. Sunken Island restoration area, 28 November 1984, with band of Spartina alterniflora and higher marsh of Avicennia germinans, Laguncularia racemosa, and Paspalum vaginatum.

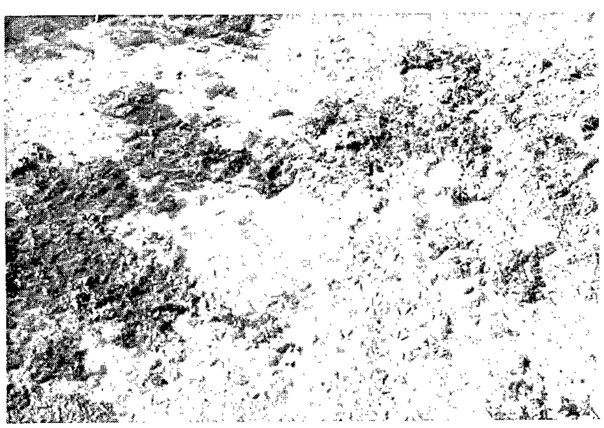


Figure 23. Productive tidal flats with decomposing drift algae (Ulva sp.) at west end of Sunken Island addition.

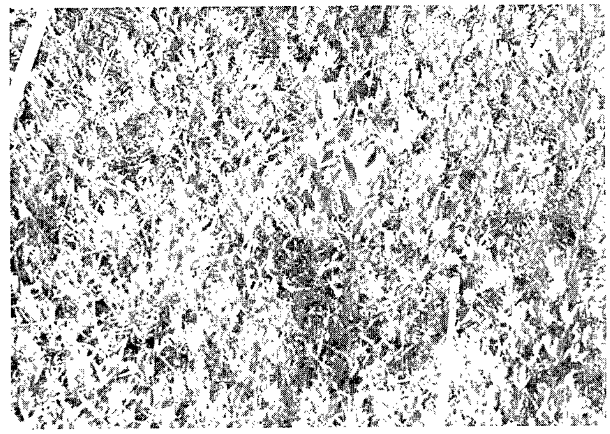


Figure 24. High marsh quadrat surveyed in Transect 3, 28 November 1984. Dominated by Salicornia virginica and Avicennia germinans recruits.

Plant species composition and density were assessed at intervals along four transects (Figure 21, Table 8). The average density of S. alterniflora at stations containing this species was approximately 102 culms/m^2.

The shoreline, as indicated by comparing available aerial imagery, appeared to have been stabilized by the 20- to 50-ft band of S. alterniflora. At slightly higher elevations, the S. alterniflora was acting as a predecessor to mangrove colonization as suggested by Lewis and Dunstan (1976a). Many young mangroves were growing at approximately the mean high water (MHW) level. Sunken Island was an extensive rookery prior to the addition of the extension, and the increase in mangrove habitat should enhance its use by birds. The shallow intertidal shoreline has provided some intertidal area for shorebird foraging. Organisms observed and collected in 10-m seine tows during the field assessment are listed in Table 9.

e. Evaluation. Planting S. alternifora on the dredge-material extension of Sunken Island successfully accomplished most of the goals of the project as stated in the project description. The growth of mangroves in

Table 8. Vegetation within the 1-m^2 quadrats along each transect line at Sunken Island.

	Transect[a]			
Station	1	2	3	4
1	85 Sa 80% Usp.	30 Sa	56 Sa	106 Sa
2	204 Sa 5 Lr 2 Ag	108 Sa 1 Ag	168 Sa 1 Rm	30 Sa
3	40 Sa 25 Lr 2 Ag	192 Sa 4 Lr 4 Ag 1 Rm 80% Usp.	38 Rm 15% Sp & Pv	6 Lr 1 Ag 80% Sp
4	2 Ag 1 Lr 80% Usp.	100% Pv		

[a]Sa = Spartina alterniflora (no. of culms)
Lr = Laguncularia racemosa (no. of individuals)
Ag = Avicennia germinans (no. of individuals)
Rm = Rhizophora mangle (no. of individuals)
Sp = Sesuvium portulacastrum (% coverage)
Pv = Paspalum vaginatum (% coverage)
Usp. = Ulva sp. (windrow from the subtidal area).

the planted S. alterniflora may reduce the available habitat for nesting Clapper Rails and Willets. The vegetation stabilized the substrate in the core area; however, the west side of the extension is eroding. Increased foraging area was provided for shorebirds. The variety of habitats (mangrove, S. alterniflora, sandy intertidal, and shallow subtidal) should provide feeding, nesting, and breeding sites for many species.

A unique feature of this project was that Sunken Island is a protected bird sanctuary with limited access (a boat is required). Limiting public access to the project has been important in the success of this project as a wildlife habitat.

1.3.6 Apollo Beach

a. Description. Apollo Beach is a development in Hillsborough County, on the south side of Tampa Bay (Figure 2). As mitigation for illegally denuding 110 ha of mangrove forest for expansion of the Apollo Beach development, a developer was required to restore the denuded area.

In October 1971, a 110-ha+ wetlands area southwest of Apollo Beach to Wolf Creek was denuded of vegetation by bulldozer. The USACE directed Frandorson Properties to cease and desist all work bayward of MHW. Finding that the area did not "rejuvenate" itself, the USACE began litigation for restoration in 1974.

Table 9. Organisms observed at Sunken Island during the 27 November 1984 field assessment.

Invertebrates

Melampus bidentatus (common marsh snail)
Littorina irrorata (marsh periwinkle)
Geukensia demissa (ribbed mussel)
Melongena corona[a] (Florida crown conch)
Uca spp. (fiddler crabs)
Xanthidae Unid. spp.[a] (crabs)
Portunidae Unid. spp.[a] (crabs)
Penaeus duorarum[a] (pink shrimp)
Palaemonetes pugio[a] (grass shrimp)
Limulus polyphemus (horseshoe crab)

Vertebrates

Fundulus grandis[a] (Gulf killifish)
Fundulus sp.[a] (killifish)
Gobiosoma sp.[a] (goby)
Raja sp.[a] (skate)
Calidris alba (Sanderling)
Ardea herodias (Great Blue Heron)
Pelecanus occidentalis (Eastern Brown Pelican)

[a] Collected in 10-m seine.

Detweiler et al. (1975) completed a study of the area 4 years after destruction and slightly before restoration. Their study area included wetlands north and south of Wolf Creek. Two transects of an undisturbed and a disturbed central area were selected and investigated for plant species within given areas spaced at intervals along each transect from upland to the bay (Figure 25). Mangrove distribution appeared to have a classical pattern in the control area (Davis 1940), with *R. mangle* found most seaward followed by mixed *A. germinans* and *L. racemosa*. In the disturbed area, however, mangrove distribution did not show clearly marked zonation. *Avicennia germinans* and *L. racemosa* had merged and appeared evenly distributed along the transect. A few *R. mangle* appeared near mosquito ditches at the bayward end of the transect. Herbaceous plants, *S. virginica* and *S. alterniflora*, had replaced the mangroves, *A. germinans* and *L. racemosa*, in importance within the disturbed area. The planting of *R. mangle* seeds (propagules) was recommended by USFWS.

b. *Mitigation/restoration plan.* The original plan negotiated by the developer and the USFWS included the following regulations:

1) planting the area delineated westward (waterward) of a mosquito ditch which parallels the shoreline from Wolf Creek to the northeast edge of "Lemon Grove," south of the Apollo Beach development.
2) planting *R. mangle* propagules in 30-ft wide bands spaced 150 ft apart, parallel to the shore.
3) placing propagules 1 ft on center, within the bands of planting.
4) allowing experiments by other parties, e.g., the University of South Florida or Hillsborough Community College.

The plan, prepared and completed by the developer's consultant, West Coast Engineering Corporation, varied the number of propagules within a 30-ft wide band from 1 to 5 ft on center (Figure 25). The project, completed in August 1974 at a cost of about $15,000, required a total of 101 work-days and resulted in the planting of 25,300 seeds over 1.6 ha.

c. *Monitoring data.* The restoration project was inspected by USFWS representatives on 26 August 1974, 3 weeks after the planting (Figure 26). Floating debris had removed many propagules; an

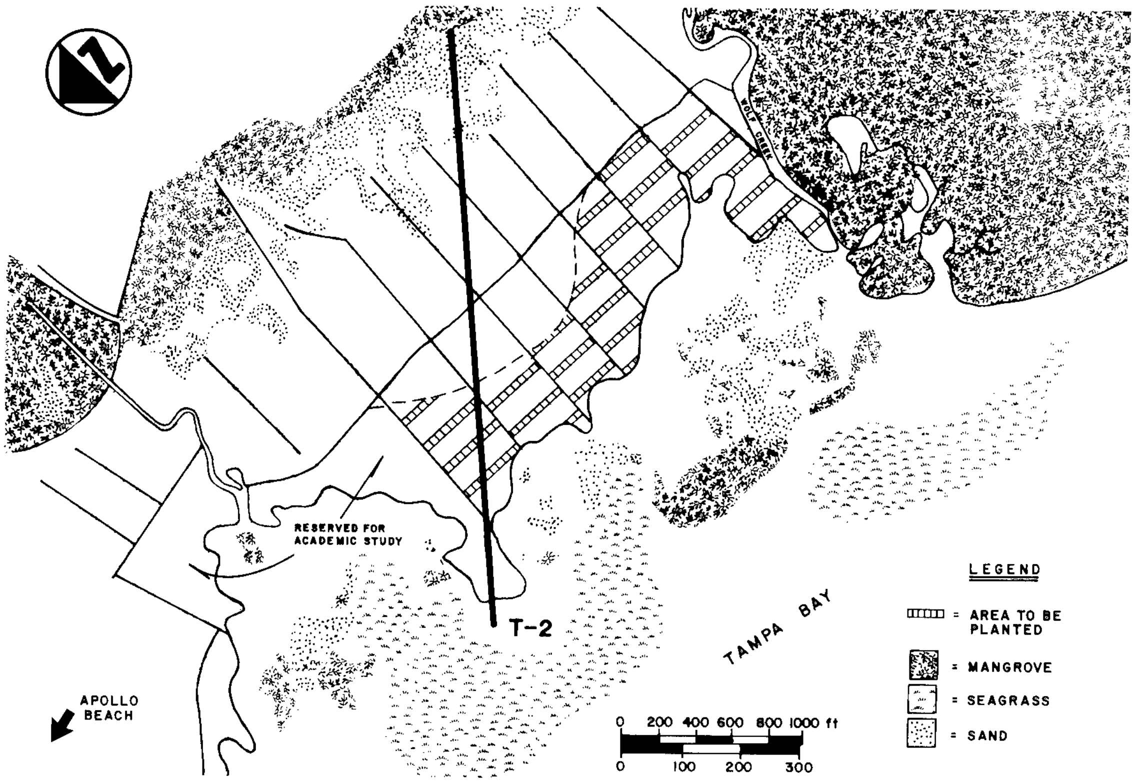


Figure 25. Mitigation plan for the Apollo Beach site. Transect T-2 (Detweiler et al. 1975) indicated (adapted from West Coast Engineering Corp. 1975).

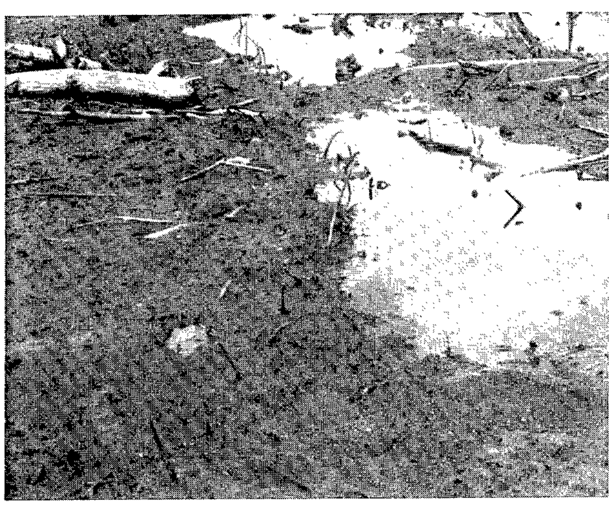


Figure 26. Frandorson property at Apollo Beach 26 August 1974, 3 weeks following planting of Rhizophora mangle propagules.

estimated 67% to 75% remained on site. The propagules had 5- to 6-cm long roots. Few leaves were evident.

During a site visit by USFWS representatives in November 1974, it was reported that fewer than 50% of the propagules appeared viable. Laguncularia racemosa and S. alterniflora dominated the restoration area. Nine months later, the site was visited again. Although no written assessment was found in the USFWS files on this visit, notes were written on the photographs (e.g., Figure 27). Significant growth and natural recruitment by L. racemosa and A. germinans was found. Those R. mangle propagules that had survived were 0.3 to 0.46 m tall, with 6 to 10 leaves.

Figure 27. Frandorson property 9 months following restoration. Majority of seedlings are white (Laguncularia racemosa) or black (Avicennia germinans) mangroves from natural recruitment or new growth from remaining root stock.

d. Field assessment. The salt-barren, landward portion and the waterward extent of the disturbed area north of Wolf Creek was visited by CSA scientists 26 November 1984. The salt barren was predominantly a barren sand area; vegetation consisted of a low percent cover of Sesuvium portulacastrum, S. virginica, and small A. germinans and Limonium carolianum.

The restoration site was investigated by means of a single transect from the bay into the mangrove stand (Figure 28). Stations consisted of observations of mangrove dominance and height within 3 m^2 sampling areas at 100-ft intervals along the transects. The transect was terminated at 1,000 ft. This terminus point was estimated to be beyond the restoration area. Mangrove vegetation continued for 600 to 800 ft beyond the terminus of the transect.

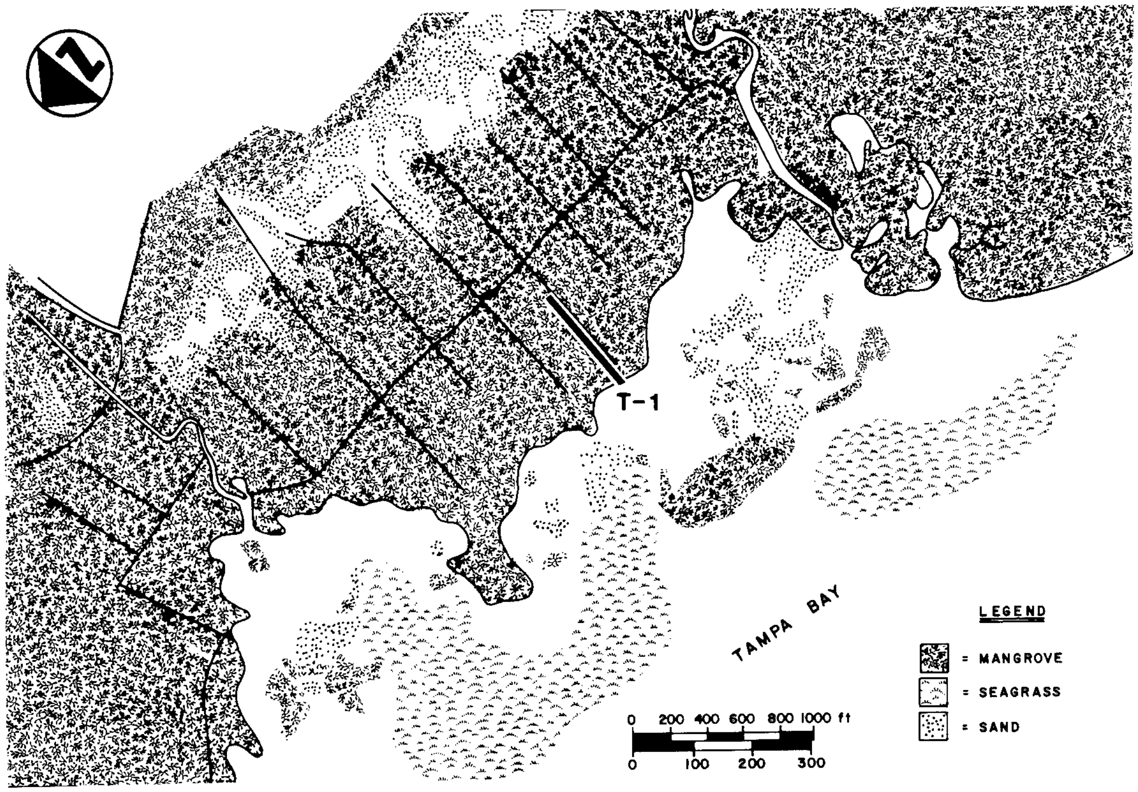
Mangrove species observed at each station are listed in Table 10. Average density of mangroves along the transect ranged from 30 to 50 plants/3 m^2. As found in the 1975 study by Detweiler et al., the predominant vegetation was L. racemosa and A. germinans, which formed very dense stands that were difficult to walk through (Figures 29 and 30). Most of the L. racemosa and A. germinans showed evidence of considerable freeze damage from the 1983 December freeze. New growth extended only up to 2 ft in height above the base of the trees. Individual R. mangle trees, approximately 6.5 ft high, were found at every station along the transect and showed no sign of freeze damage. Observations to the north of the transect indicated the presence of viable R. mangle extending above the dead growth of A. germinans and L. racemosa. Whether these individuals were planted is difficult to ascertain, however, the probability of R. mangle seeds reaching these interior areas is low. Organisms observed at the Apollo Beach restoration site are listed in Table 11.

e. Evaluation. The attempt to restore wetlands denuded in 1971 at Apollo Beach represents an early experiment with restoration, and demonstrates natural reforestation within a wetlands area in Tampa Bay. The study by Detweiler et al. (1975) clearly identified the initial stages of natural reforestation of mangrove wetlands areas and the differences in the capability of mangrove species for reinvasion of denuded areas. Rhizophora mangle lacked both the ability for vegetative regrowth from the remaining root systems and, in this instance, a seed source. The poor survivorship of the R. mangle propagules planted in distinct patterns suggests that the same results could have been achieved by random plugging or broadcasting (Teas 1972).

The destruction of the original mangrove forest removed this habitat from the Tampa Bay system for an extended period of time. Aerial imagery of Apollo Beach demonstrates the slow process of natural reforestation. Comparisons with the mature mangrove forest south of Wolf Creek show that the restored area has not yet recovered. The recovering area appears more susceptible to freeze damage than the adjacent mangrove forests.

1.3.7 Branches Hammock

a. Description. Restoration of Juncus wetlands within Branches Hammock was required of the FDOT for wetland losses incurred during construction of Interstate 75. Branches Hammock is a tidal creek connected to the Manatee River, surrounded by a tidally inundated Juncus roemerianus (needlerush) marsh



Habitat map and location of the survey transect (T-1) for the 27 November 1984 field assessment of the Apollo Beach site.

Figure 29. Mangrove habitat at east end of transect, 28 November 1984, 10 years after illegal clearing. Freeze-damaged white (Laguncularia racemosa) and black (Avicennia germinans) mangroves in foreground and taller red (Rhizophora mangle) and white (L. racemosa) mangroves in background.

Figure 30. Mangrove community at west end of transect, 28 November 1984, dominated by red (Rhizophora mangle) mangroves in foreground and dense black (Avicennia germinans) and white (Laguncularia racemosa) mangroves in background.

Table 10. Mangroves listed to relative importance at stations (3 m^2) along a single transect of Apollo Beach.

Station		Species and height[a]
1	Bayward end	Rm 0.5 - 2 m Ag 0.5 - 2 m Sa
2		Ag 2 m Rm 2 m
3		Lr 2.5 m Ag 2.5 m Rm 2.5 m
		Tidal Creek
4		Lr 2.5 m Ag 2.5 m Rm 2.5 m
5		Lr 2.5 m Ag 1.5 m Rm 2 m
6		Ag 3 m Lr 2 m Rm 2 m
7		Ag 2.5 m Lr 2 m Rm 2 m
8		Lr 2.0 m Rm 2.0 m
9		Lr 1.0 m Ag 1.5 m Rm 1.5 m
10	Landward end	Lr 1.0 m Ag 1.5 m Rm 1.5 m

[a]Sa = *Spartina alterniflora*
Lr = *Laguncularia racemosa*
Ag = *Avicennia germinans*
Rm = *Rhizophora mangle*.

Table 11. Organisms observed at Apollo Beach during the 27 November 1984 field assessment.

Invertebrates
Melongena corona (Florida crown conch)
Cerithiidae (Cerithid snails)
Uca spp. (Fiddler crabs)
Vertebrates
Eucinostomus argenteus (spotfin mojarra)
Lagodon rhomboides (pinfish)
Eudocimus albus (White Ibis)
Casmerodius albus (Great Egret)
Ardea herodias (Great Blue Heron)
Butoredes striatus (Green Heron)
Pelecanus occidentalis carolinensis (Eastern Brown Pelican)
Megaceryle alcyon (Belted Kingfisher)

(Figure 2). The construction of the two parallel bridges (18.3 m x 347.0 m and 18.3 m x 475.5 m) required that permanent fill be placed on 0.54 ha and temporary (6 to 9 months) fill and workmats or roadway be placed over 2.32 ha of salt marsh.

b. Mitigation/restoration plan. Under a contract let by the FDOT, revegetation with black needlerush (*Juncus roemerianus*) was done in June and July 1980 (Figure 31).

The areas to be planted were prepared for revegetation by the bridge contractor by excavating the existing marsh sediment (peat, muck) to a minimum depth of 30 inches or through the entire depth of the sediment layer and stock piling the sediment. Once construction was complete the temporary fill roads were to be removed to 12 inches below the original

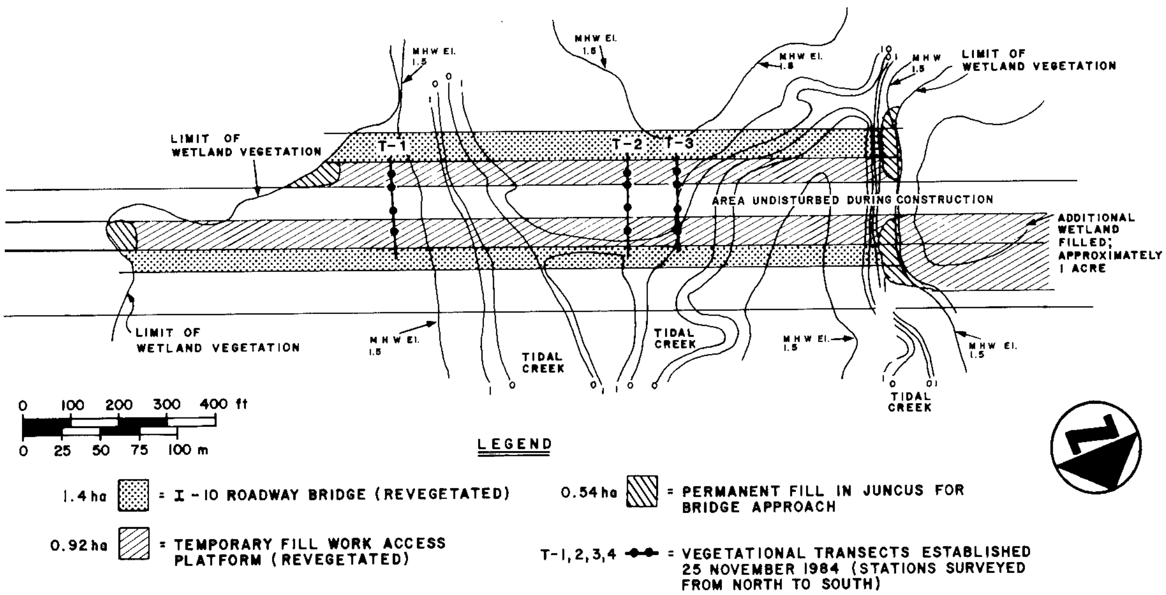


Figure 31. Site diagram and transects for the 25 November 1984 field assessment at the Branches Hammock site (From FDOT State Job No. 13075-3404, 16 March 1978).

marsh elevation. The stockpiled muck was to be used to return the affected area to the original elevation.

Plants were to be collected from within the right-of-way in very localized areas close to the revegetation site because it was felt that trampling of the marsh could be as damaging as actual plant removal. The clumps were to be trimmed back to a height of 8 to 12 inches prior to digging. Plugs at least 15.2 cm in diameter and 10 inches deep were to be removed and used in planting.

Twenty-one thousand (21,000) plugs of J. roemerianus were removed and planted on 1.2-m centers with one ounce of 14-14-14 Osmocote® slow-release in all areas in which fill roads had previously been built and in any and all other areas as designated by the Department (Florida Department of Transportation State Job No. 13075-3404, 1978).

c. Monitoring data. The consultant reviewed the project 22 months after planting (Lewis 1982a). The Juncus roemerianus was found to spread much more slowly than S. alterniflora, which coalesced from plugs on 1-m centers in two growing seasons. Plugs planted under the bridges failed completely. Minimal expansion of the planted plugs was found in areas that were infrequently inundated by the tide. Plugs planted at low elevations and receiving regular tidal inundation (MHW elevation [El.] 1.5, see Figure 31) expanded approximately 25-fold, from an average of 12 shoots/plug when transplanted to an average of 300 shoots/plug in 22 months. Competition from other plant species was reduced at low elevations. Coalescence of the plugs was seen in only a few cases. The overall estimate of survivorship of the 21,000 planted plugs was 50%. Greatest survivorship was found at low elevations adjacent to the natural marsh.

d. Field assessment. Continental Shelf Associates, Inc. (CSA) scientists visited the site on 25 November 1984 at 1500 h (approximately 4 h after low tide), approximately 4.5 years after revegetation. Plant species composition and percent cover were assessed (Figure 32) at equidistant intervals along

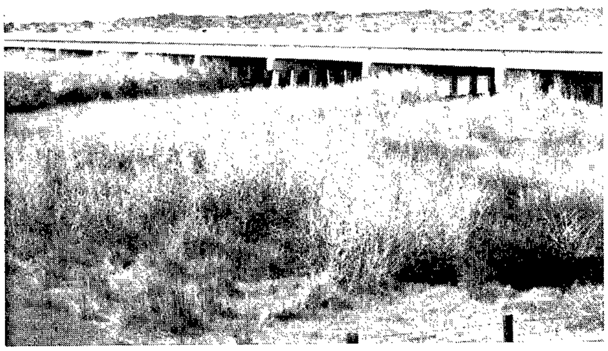


Figure 32. South end of Branches Hammock mitigation site, 26 November 1984, 4.5 years following revegetation with *Juncus roemerianus*.

three transects between the bridges (Figure 31). The data are listed in Table 12.

The project affected areas beneath and between the bridges as reported in the 22-month monitoring; no vegetation existed beneath the bridges. Revegetation has occurred between the bridges though not entirely by *J. roemerianus*. The monospecific stand of *J. roemerianus* (Figure 33) between the haulroads was left undisturbed during construction. Pockets of ponded water within a narrow tidal creek existing within the *J. roemerianus* marsh contained *Ruppia maritima* (Figure 34). The area in which the haulroads had been constructed, however, was not returned to the previous elevation or sediment type. The elevation is slightly higher than the surrounding marsh and the sediment contains sand and shell from haulroad construction. In

Table 12. Vegetation (percent cover) within the 1-m^2 quadrats along each transect line at Branches Hammock.

	Transect[a]		
Station[b]	1	2	3
1	90% Jr 5% Sv & Bm 5% Lr	90% Jr 10% Sv & Bm	40% open 30% Jr 30% Lr
2	25% Jr 75% Lr	50% Jr 25% Pv 25% Sv & Bm	50% Lr 30% Jr 20% open
3	100% Jr	100% Jr	100% Jr
4	40% Rm 30% Jr 30% Lr	60% Lr 20% Jr 20% open	50% open 30% Lr 20% Jr

[a]Jr = *Juncus roemerianus*
Sv = *Salicornia virginica*
Bm = *Batis maritima*
Lr = *Laguncularia racemosa*
Rm = *Ruppia maritima*
Pv = *Paspalum vaginatum*.
[b]See Figure 31 for approximate station locations.

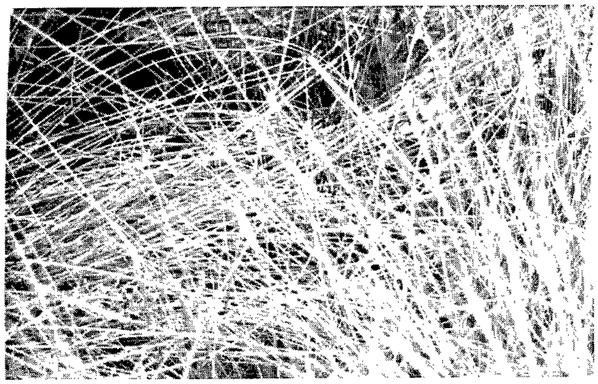


Figure 33. Dense growth of Juncus roemerianus in undisturbed central marsh.

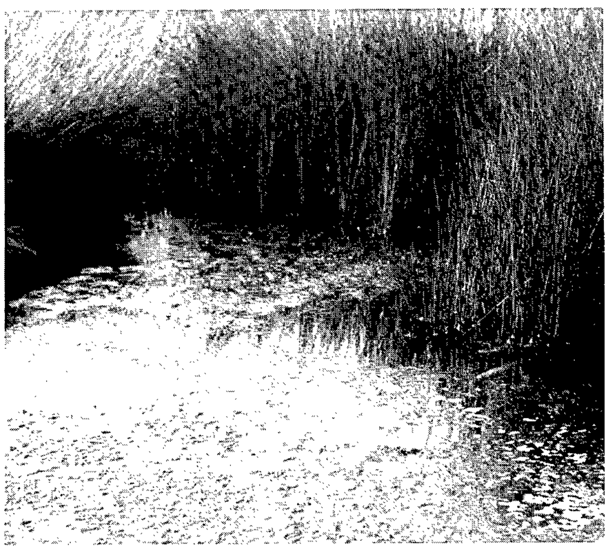


Figure 34. Shallow tidally connected pond in central marsh with submerged widgeongrass (Ruppia maritima).

comparison, the soil within the marsh is a fine organic mud. The combination of higher elevation and sand/shell soil allowed for the invasion of transitional wetlands vegetation into the haulroad areas. Laguncularia racemosa, P. vaginatum, and succulent species (Batis maritima and S. virginica) invaded these areas (Figure 35).

Fishes and wildlife observed during the field assessment are listed in Table 13.

Figure 35. Area of unsuccessful Juncus roemerianus restoration, dominated by Salicornia virginica, Paspalum vaginatum, and stunted J. roemerianus.

Table 13. Organisms observed at Branches Hammock during the 25 November 1984 field assessment.

Invertebrates
Batillaria minima (False horn shell)
Melampus bidentatus (Common marsh snail)
Polymesoda caroliniana (Carolina marsh clam)
Uca spp. (Fiddler crabs)
Vertebrates
Cyprinodon variegatus (Sheepshead minnow)
Fundulus grandis (Gulf killifish)
Hydranassa tricolor (Tricolored Heron) heron tracks
Procyon lator (raccoon) tracks

e. Evaluation. This mitigation project was partially successful in its goal of restoring 2.32 ha of J. roemerianus marsh. None of the 1.4 ha planted under the bridge spans survived, and of the 0.92 ha temporarily filled and later restored, only 50% was restored to a monospecific J. roemerianus marsh. A high marsh dominated by P. vaginatum, S. virginica, and B. maritima was created in the other 50% of this area (Figure 35). Plantings close to the tidal creeks and central marsh showed considerable coalescence. The lack of success of J. roemerianus transplants in the present high marsh is attributable to the inability of the construction contractor to properly restore the marsh substrate and return the area to previous elevations. The sand/shell used for the temporary work roads was not effectively removed.

The loss of wetland to the permanent fill (0.54 ha) was not compensated for in this project. The habitat under the bridges (1.4 ha) should have been included as permanent loss, since plant growth of natural vegetation under these low elevation bridges appears impossible. These losses (approximately 2 ha) were not replaced by this project and are a net loss of wetlands.

Mitigation for these losses should have required on-site creation of J. roemerianus marsh from adjacent upland; this is an example of a situation wherein off-site, but within-watershed, restoration of in-kind habitat might be desirable if suitable habitat were available.

1.3.8 Feather Cove

a. Description. As mitigation for destruction of 4 ha of mangrove forest, the developer, Feather Sound, Inc., was ordered to create 3.1 ha of S. alterniflora marsh. The restoration project at Feather Cove in Pinellas County (Figure 2) was performed by the developer as the result of enforcement action taken by Federal, State, and County environmental regulatory agencies. Feather Sound, Inc. had, prior to 21 January 1983, destroyed approximately 4 ha of mangrove wetlands to construct a berm around an existing borrow pit at the Feather Sound development. The corporation agreed to restore 3.1 ha of wetlands.

b. Mitigation/restoration plan. The 11-ha borrow pit and restoration area are shown in Figure 36. The restoration plan, prepared by Mangrove Systems, Inc. (1983), involved removal of 3.1 ha of fill to elevation +1.5 ft National Geodetic Vertical Datum (NGVD) ±0.5 ft; fill or excavation of 0.63 ha of existing mosquito ditches to -1.0 ft NGVD ±0.5 ft; and excavation of another 0.12 ha of disturbed mangrove vegetation to ±1.5 ft NGVD

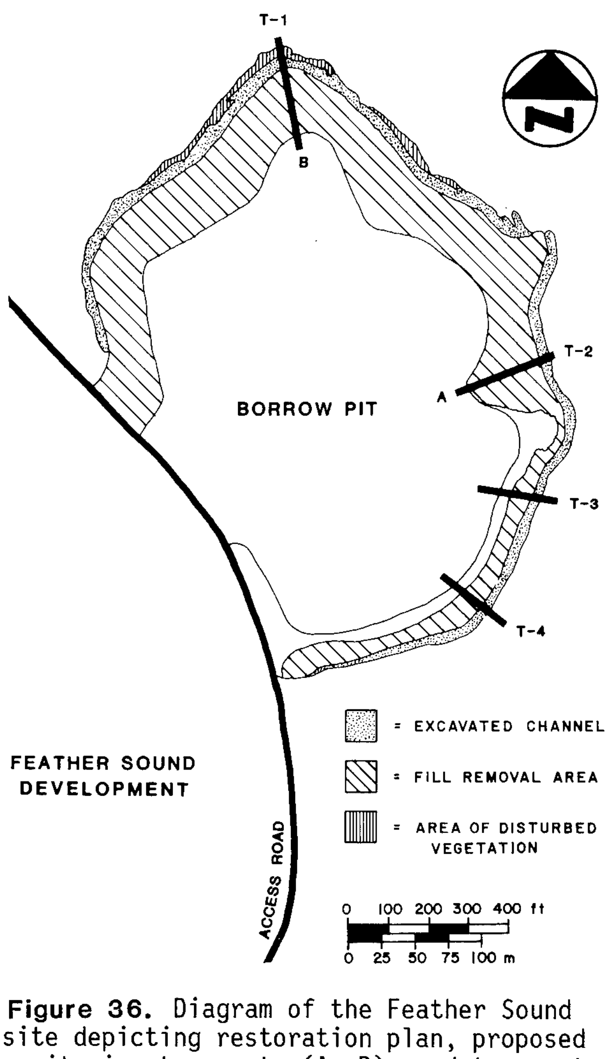


Figure 36. Diagram of the Feather Sound site depicting restoration plan, proposed monitoring transects (A, B), and transects (T-1 through T-4) surveyed during the 26 November 1984 field assessment (modified from Mangrove Systems, Inc. 1983).

+0.5 ft. After the elevation changes, the area was to be planted with 37,752 sprigs of S. alterniflora on 3-ft centers in the 3.1-ha area of excavated fill (Figure 36).

The final graded elevation of +1.5 ft NGVD was chosen because that elevation was slightly lower than the +2.0 ft NGVD elevation of the existing mangroves surrounding the project site. The existing mosquito ditches were altered to -1.0 ft NGVD elevation to assure that there would be some level of water in them at all times. This was proposed to enhance fish and invertebrate habitats and, because the depth is within the euphotic zone of the water column, enhance the potential for colonization of R. maritima (widgeon grass), an important habitat and food source in Old Tampa Bay.

A small area (0.6 ha) was planted with S. alterniflora in May 1983. The remaining 2.5 ha was planted in May 1984. The estimated total cost of the restoration was $40,000; in addition, Feather Cove, Inc. agreed to pay $75,000 to the State of Florida "Pollution Recovery Fund" over a 3-year period.

c. Monitoring data. The revegetation site at Feather Cove was monitored by Mangrove Systems, Inc. on 20 December 1984, approximately 6 months after completion. The 0.6 ha area planted in May 1983 had a mean density of 131.3 $\pm$ 62.0 culms/m^2 and was estimated to have a 90% cover of S. alterniflora and 10% cover of Paspalum distichum (= vaginatum). Planting of a large (2.5 ha) area conducted in May 1984 was not as successful. Flooding of that area led to failure (less than 10% survival) of the planting. The general lack of tidal flushing was the cause of the flooding, along with stormwater and dewatering discharges into the area.

d. Field assessment. Continental Shelf Associates, Inc. (CSA) scientists visited the Feather Cove site on 26 November 1984, approximately 6 months after the restoration was completed. The difference between the areas planted one year apart was obvious. The 0.6 ha area planted in May 1983 (Figure 37) was successful as indicated by the culm densities recorded along Transects 3 and 4 (Figure 36 and Table 14).

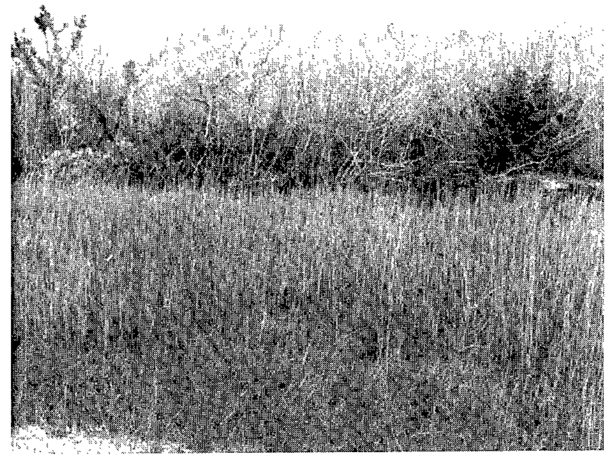


Figure 37. Transect 4 in the area previously restored in May 1983 (Spartina alterniflora, Paspalum vaginatum, and Salicornia virginica) at Feather Cove; adjacent mangrove habitat in background.

The 2.5 ha area site was completely inundated with approximately 15 cm of water and nearly devoid of vegetation (Figures 38 and 39). Spartina alterniflora sprigs were observed

Table 14. Numbers of Spartina alterniflora culms in 1-m^2 quadrats along transects at Feather Cove restoration site.

	Transect			
Station	1	2	3	4
1	0	0	232	108
2	0	0	168	168
3	0	0	160	156
4	0	0	152	mosquito ditch
5	0	0	mosquito ditch	-

Figure 38. Area (Transect 1) planted with *Spartina alterniflora* 12 May 1984, as observed on 29 November 1984. Mangrove habitat in background shows existing habitat prior to unauthorized clearing.

Figure 39. Area (Transect 2) planted with *Spartina alterniflora* 12 May 1984, as observed on 29 November 1984. A few sprigs are noticeable in the background, with *Paspalum vaginatum* in higher area.

throughout the site. Sparse patches of *R. maritima* were also observed within the site.

The site consisted of an intertidal sandy bottom habitat adjacent to a mangrove wetlands forest (Figure 39) dominated by *A. germinans* and *L. racemosa* and a previously planted *S. alterniflora* marsh. This combination of habitats supported an interesting and diverse fish and wildlife habitat. The organisms observed during the field assessment are listed in Table 15.

Plant species composition and density were estimated every 15 m along four transects at locations indicated in Figure 36. The results of these counts

Table 15. Organisms observed at Feather Cove restoration site during the 26 November 1984 field assessment.

Invertebrates
Melongena corona (Florida crown conch)
Cerithiidae (Cerithid snails)
Uca spp. (Fiddler crabs)
Vertebrates
Poecilia latipinna (Sailfin molly)
Eudocimus albus (White Ibis)
Hydranassa tricolor (Tricolored Heron)
Pelecanus occidentalis carolinensis (Eastern Brown Pelican)
Anas platyryhnchos (Mallard)
Limnodromus griseus (Short-billed Dowitcher)
Pluvialis squatarola (Black-bellied Plover)
Tringa flavipes (Lesser Yellowlegs)
Calidris alpina (Dunlin)
Calidris mauri (Western Sandpiper)
Calidris pusilla (Semipalmated Sandpiper)
Catoptrophorus semipalmatus (Willet)
Phalacrocorax auritus (Double-crested Cormorant)
Megaceryle alcyon (Belted Kingfisher)

are reported in Table 14. Spartina alterniflora did not exist along the transects within the 1984 restoration site (Figure 38). In the area previously planted south of this site, S. alterniflora averaged 163 culms/m^2 along two transects (Table 14).

e. Evaluation. The restoration at Feather Cove was a partial failure in terms of its attempt to plant S. alterniflora. Failure was apparently due to the lack of tidal flushing in the planting area and submersion of the planting area for greater periods than can be tolerated by S. alterniflora. Of the 37,752 S. alterniflora sprigs planted in 1984, fewer than 25% survived.

The combination of mangrove, S. alterniflora, shallow subtidal, and intertidal flat habitats seen at Feather Cove supported the most diverse assemblages of birds observed during this study. Ruppia maritima was not observed in the created mosquito ditches; further monitoring of the ditches for vegetation, invertebrates, and fishes is needed.

1.3.9 Harbor Island

a. Description. This project involved restoration of a mangrove preserve to replace wetlands destroyed for development. The Harbor Island project resulted in an early attempt to plant R. mangle in recreated wetlands and an expansion of the USACE jurisdiction into tidal wetlands under the 1972 amendments to the Federal Water Pollution Control Act (FWPCA). Harbor Island represents a large loss (approximately 10 ha) of mangrove wetlands to upland development in the Papy's Bayou, Pinellas County area (Figure 2).

While waiting for issuance of the USACE permit to dredge and fill, the developers, W. Langston Holland and Ruth B. Kirby, destroyed approximately 10 ha of wetlands in an area they contended was landward of MHW (Figures 40 and 41). The U.S. Environmental Protection Agency (EPA) took the matter to court and obtained a temporary restraining order on 21 December 1973. Judge Ben Krentzman, U.S. District Court, Middle District of Florida, Tampa Division, issued a Memorandum Opinion in

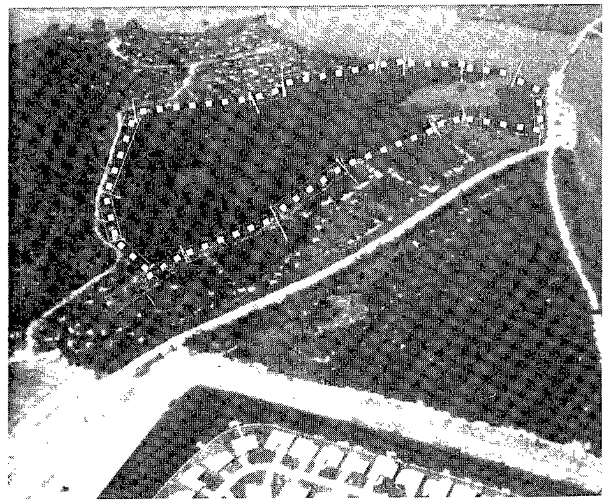


Figure 40. Aerial (1973) of Harbor Island site prior to illegal dredge-and-fill. Site of present mangrove preserve and subtidal lagoon indicated by dotted line.

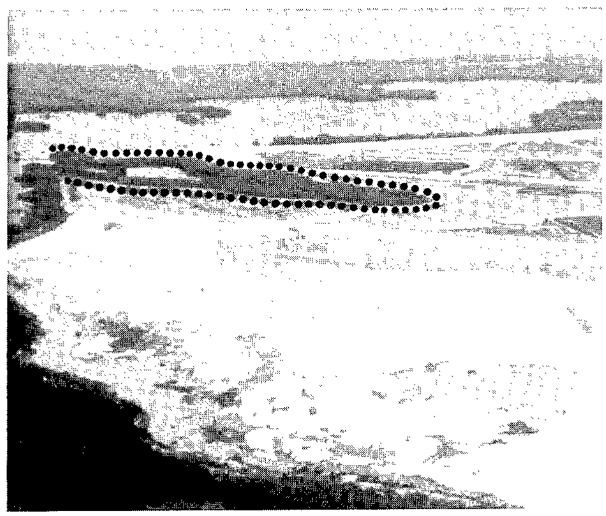


Figure 41. Aerial (1974) of Harbor Island following illegal dredge-and-fill. Site of present mangrove preserve and lagoon indicated by dotted line.

March 1974 which stated (U.S. District Court vs. W. Langston Holland, 1974):

> That the mean high water line is no limit to Federal authority under the FWPCA. While the line remains a valid demarcation for other purposes,

> it has no rational connection to the aquatic ecosystems which the FWPCA is intended to protect. Congress has wisely determined that Federal authority over water pollution properly rests in the Commerce Clause and not on past interpretations of an act designed to protect navigation. And the Commerce Clause gives Congress ample authority to reach activities above the mean high water line that pollute the waters of the United States.

The Final Decree ordered the defendants (applicants) to perform all work necessary to allow establishment of 31.4 ha of mangrove preserve area which is to remain as a natural environmental area in perpetuity and to obtain all necessary permits before proceeding with completion of the planned 112 ha project.

b. Mitigation/restoration plan. Most of the 31.4-ha mangrove preserve (the area north of the dike detailed in Figure 42) whose establishment was required by the Final Decree already existed as mangrove wetlands on the property. The area designated the "central preserve," however, had been large mangrove wetlands, but was cleared, channelized, and filled during the illegal development. The extent of the restoration in 1974 included recontouring and flooding of the area, and an attempt to plant an estimated 2,000 to 3,000 *R. mangle* seeds at a cost of $1,250 (Figure 42). A part-time employee planted the seeds, few of which successfully germinated and grew. *Rhizophora mangle* trees exist on the site in areas designated for revegetation (Figure 42), and serve as a plentiful on-site seed source. The *R. mangle* individuals could be natural recruits.

c. Monitoring data. The area was visited on 6 May 1975 by individuals representing the EPA, USACE, and the developer. The elevation of the "central preserve" was found to be improper. The depths in the open water area south of the existing mangroves was too great (in some places greater than -2.5 m mean sea level [MSL]).

d. Field assessment. Continental Shelf Associates, Inc. (CSA) scientists visited the Harbor Island restoration site on 28 November 1984 at midtide of a 0.6-m tidal range. Our observations indicate that the "central preserve" had not been recontoured to 0.0 to 0.5 m MSL as requested by the EPA after the 6 May 1975 site visit. Most of the bottom in the "central preserve" exists below MLW, which precludes the opportunity for mangrove recruitment (Figures 42 and 43). Based on their uniform size and the degree of growth expected after 10 years, a few of the planted mangroves were recognizable on the northwest side of the preserve. Most of the larger mangroves in the "central preserve" probably were present before the development.

Basically, the "central preserve" was an open-water area behind mangroves and spoil mounds (Figure 43) separating the area from Papy's Bayou. A perimeter canal surrounded most of the preserve; a dike (Figure 42) separated the preserve from a stormwater retention lake. The perimeter canal was blocked from access to Papy's Bayou by a row of concrete pilings.

The "central preserve" was investigated by a single observational transect from the northeast corner to the western edge of the preserve (Figure 42). A 10-m seine was pulled in the open water area along the transect. Fishes and wildlife observed and captured in the seine are listed in Table 16. The high spoil mounds (> +1.5 m MSL) encountered during the transect were vegetated with *Schinus terebinthifolius* (Brazilian pepper) and a narrow band of naturally recruited mangroves (*R. mangle*, *A. germinans*, and *L. racemosa*). Water clarity was good; the medium-grain sandy bottom was visible at all times. Seagrass growth, however, was not observed within the preserve. The strong outgoing tide suggests good tidal export from the area.

e. Evaluation. The revegetation of the "central preserve" at Harbor Island to a mangrove wetlands area was not successful. Mangrove tidal creeks and mosquito ditches that existed on the site prior to development have been replaced by an open-water, subtidal habitat. The open-water habitat is important, but not rare regionally. The restoration plan allowed a band of mangroves to recruit

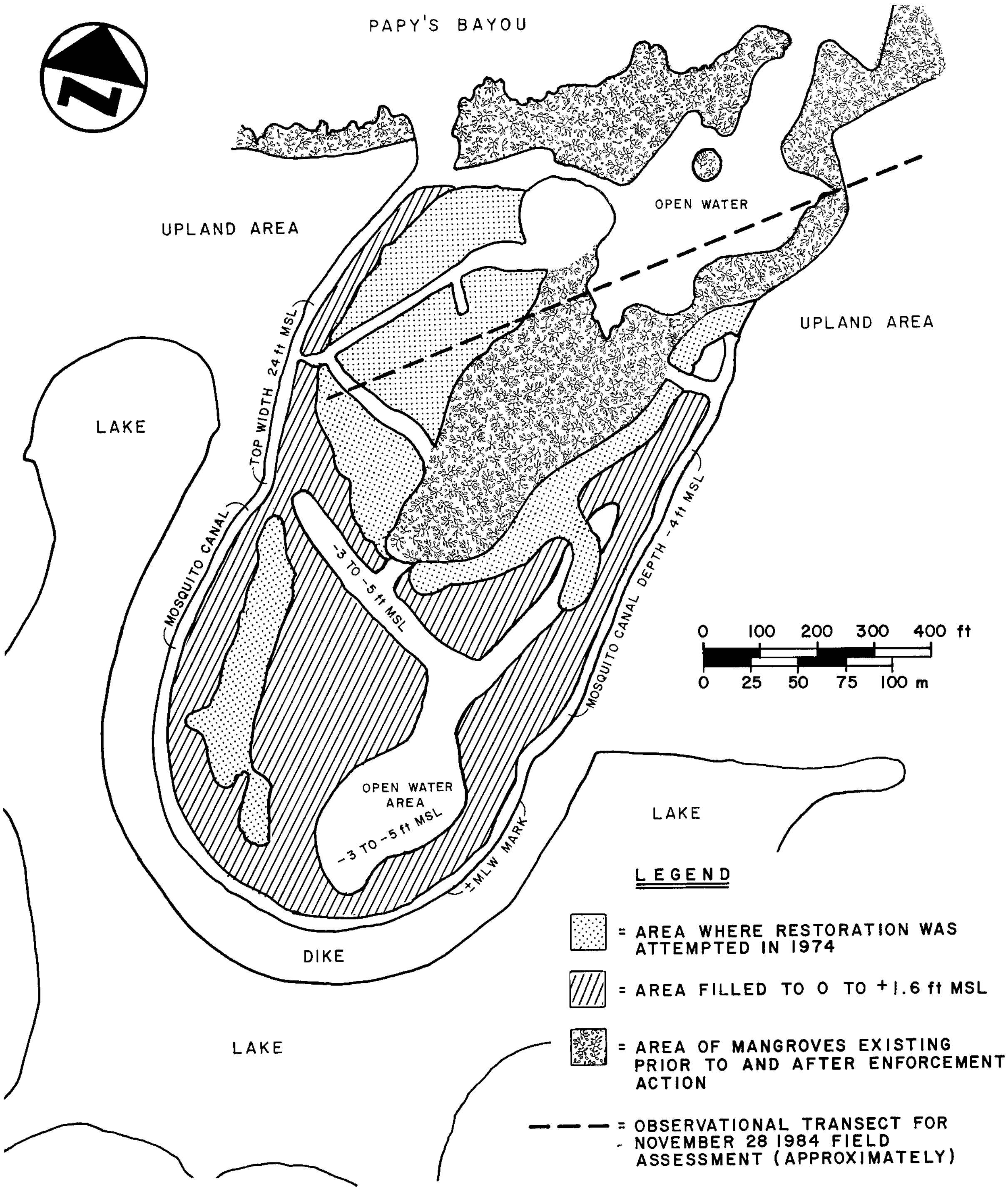


Figure 42. Harbor Island restoration plan for the "central preserve" as established by the USFWS on 15 May 1975.

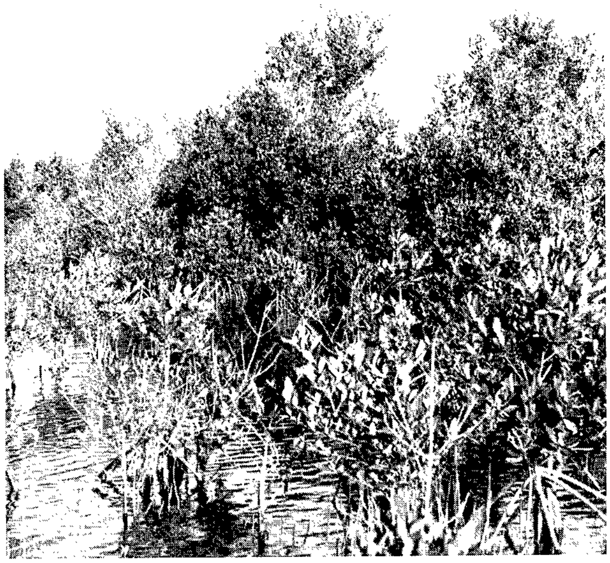


Figure 43. View of interior mangrove preserve and spoil islands, 29 November 1984.

naturally along a common easement between the development and the preserve. In fact, recruitment has been retarded or prevented by lawn maintenance practices of the residents, and in some cases existing stands of mangroves have been trimmed for vistas or boat access into the preserve (Figure 44).

Figure 44. Illegal mangrove trimming by private homeowner; north shoreline of Harbor Island's mitigation area.

Table 16. Organisms observed in the "central preserve" at Harbor Island during the 28 November field assessment.

Invertebrates
Melongena corona[a] (Florida crown conch)
Nassarius vibex[a] (bruised basket shell)
Solemya occidentalis[a] (West Indian awning clam)
Mulinia lateralis[a] (dwarf surf clam)
Spiochaetopterus costarum oculatus[a] (polychaete worm)
Vertebrates
Anchoa sp.[a] (anchovy)
Mugil sp.[a] (mullet)
Tilapia aurea[a] (blue tilapia)
Cyprinodon variegatus (sheepshead minnow)
Poecilia latipinna (sailfin molly)
Phalacrocorax auritus (Double-crested Cormorant)
Aythya marila (Lessor Scaup)
Fulica americana (American Coot)
Pelecanus occidentalis carolinensis (Eastern Brown Pelican)
Ardea herodias (Great Blue Heron)
Casmerodius albus (Great Egret)
Nycticorax nycticorax (Black-crowned Night Heron)
Megaceryle alcyon (Belted Kingfisher)

[a]Captured in 10-m seine.

This project resulted in greater jurisdiction and strength for the USACE permitting process by expanding the permitting process in relation to water quality to include all water bodies draining into navigable waters.

1.3.10 Placido Bayou

a. Description. The case of Placido Bayou involved an attempt (begun in 1982) by developer Robert D. Wray to use wetland creation to gain permits for development within wetlands (Figure 2). After denial of an application to create 0.7 ha of wetland and preserve 16.0 ha of wetland for filling of 2.3 ha of wetland for development, the applicant reduced the area of wetland to be filled to 1 ha. Mitigation was increased to scrape down 1 ha of uplands to wetlands elevations and plant *S. alterniflora*, and to preserve 16.8 ha of wetlands along the shoreline of Placido Bayou.

The USACE and FDER permits were issued with specific conditions requiring the mitigation project.

b. Mitigation/restoration plan. As indicated in Figure 45, the applicant considered developing the "subject property" according to the site data:

Proposed wetlands to be created from uplands	1 ha
Wetlands to be lost to development	-1 ha
Borrow pit	5.7 ha
Preserve	16.8 ha

The proposed wetlands were to be excavated to approximately MHW and planted with *S. alterniflora* on 0.9-m centers.

The project was excavated and planted by Sundown Construction Company in August 1983. The *S. alterniflora* plantings were purchased in pots from Environmental Wetland Nursery, Inc. Total cost of the project was estimated at $4,000 (K. I. Pierce, Sundown Construction Company; pers. comm., 1984).

c. Monitoring data. As required by the permits, the project was monitored after 1 year to assure a survival rate of at least 70% at the end of one growing season. In a 1 August 1984 letter, Sundown Construction assured 70% survival of the planted *S. alterniflora*.

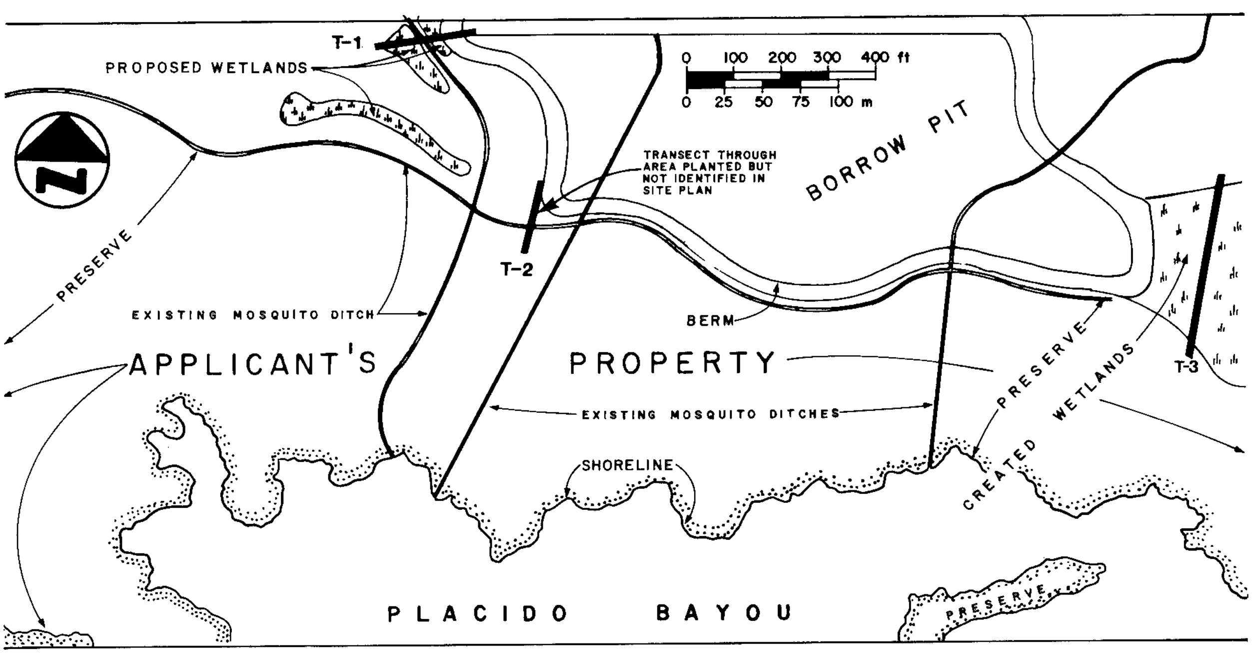


Figure 45. Site plan and field assessment transects (T-1 through T-3) for the 28 November 1984 field assessment of the Placido Bayou site (from site plan by George F. Young, Inc. 12 March 1982).

d. Field assessment. Continental Shelf Associates, Inc. (CSA) scientists visited the project site on Placido Bayou on 28 November 1984, approximately 1.25 years after creation. Constructed areas appeared well flushed tidally. Some of the S. alterniflora planting areas had spread and coalesced (Figure 46); others showed little lateral spread from the initial plantings (Figure 47). Generally, the best S. alterniflora growth was seen near the mosquito ditches (Figure 45).

Figure 46. Developing Spartina alterniflora wetlands, 1.3 years after planting, with previous upland habitat to the left of wetlands.

Figure 47. South restoration area with high mortality of Spartina alterniflora.

Species observed during this survey were Uca spp. (fiddler crabs), Mycteria americana (Wood Stork), and Ardea herodias (Great Blue Heron).

Plant species composition and density were measured using a 1-m^2 quadrat (Figure 48) placed every 15 m along a transect through each revegetation area (three transects total; Figure 45). The results (Table 17) reinforced the general observations already stated. Small L. racemosa had begun to colonize the periphery of the planting areas. The proposed wetland west of the borrow pit was not surveyed. However, a wetland constructed southwest of the borrow pit was investigated (Transect 2).

e. Evaluation. This project shows that developers have become aware of the need to mitigate wetland losses and that wetlands cannot be used indiscriminately for upland development. Most of the "subject property" within this permit was set aside as mangrove preserve (16.8 ha of the total 23.5 ha).

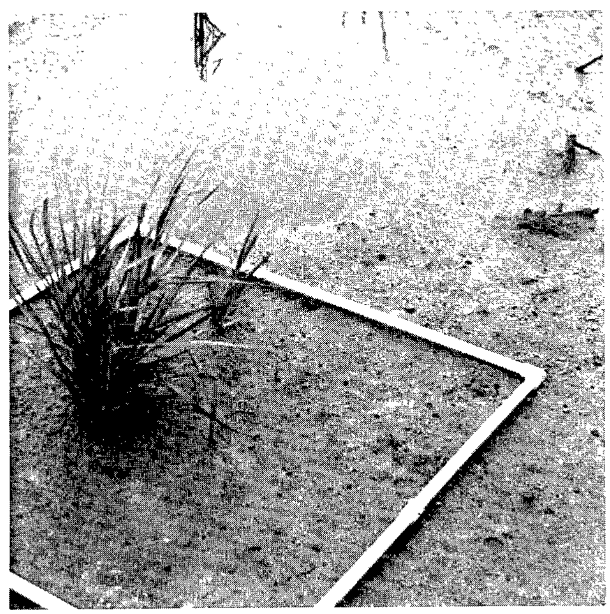


Figure 48. Spartina alterniflora plug showing lateral growth; unsuccessful plugs in background.

Table 17. Vegetation and Uca spp. (fiddler crab) holes observed within 1-m^2 quadrats at Placido Bayou.

Station	Transect[a] 1	2	3
1	1 Sa	6 Sa	152 Sa 2% Sv 5 Uca
2	13 Sa 2 Uca	0	38 Sa
3	5 Sa 4 Uca	0	0
4	Mosquito ditch	10 Sa 23 Uca	0
5	74 Sa 28 Uca	Bh [existing Lr not Ag planted] Rm	0
6	90 Sa 26 Uca	end of restoration area	14 Sa 10 Uca
7	48 Sa 32 Uca		18 Sa 5 Uca
8	65 Sa 1 Lr 17 Uca		35 Sa 3 Sv 1 Sp 24 Uca
9	44 Lr 5 Sa 10 Sv and Sp		Mosquito ditch
10	end of restoration area		66 Sa 1 Sv 14 Uca
11			208 Sa 26 Uca
12			180 Sa 29 Uca
13			26 Sa 20 Sv 1 Lr 46 Uca

[a]Sa = Spartina alterniflora (culm/m^2)
Lr = Laguncularia racemosa (plants/m^2)
Sv = Salicornia virginica (% coverage)
Sp = Sesuvium portulascastrum (% coverage)
Uca = Uca spp. (holes/m^2)
Bh = Baccharis halmifolia (presence)
Rm = Rhizophora mangle (presence)
Ag = Avicennia germinans (presence).

The S. alterniflora planted within the created wetlands is viable and will probably coalesce into a continuous marsh within 1 to 2 years. Mangrove seeds, however, have already begun drifting into the area. The area eventually will be colonized by L. racemosa and A. germinans, which already are found within the adjacent preserve.

1.3.11 Lassing Park

a. Description. A shallow, subtidal, sand habitat was created by filling what remained of a former channel off Lassing Park. The park, owned by the City of St. Petersburg, is located along Beach Drive, south of the Port of St. Petersburg within the State-designated Pinellas County Aquatic Preserve, Outstanding Florida Waters (Figure 2). As evidenced by aerial photographs in 1962 (Figure 49), a channel was constructed from Tampa Bay to a basin and boat dock in the shallow area adjacent to Lassing Park between 1945 and 1960. The waterward end of the channel, filled in through time, left a 3.9 ha deep hole near the beach. Approximately 9.6 ha of seagrasses, consisting predominantly of Halodule wrightii (shoalgrass) and Thalassia testudinum (turtle grass), exist immediately south of the hole.

b. Mitigation/restoration plan. In 1983, as a result of two children drowning

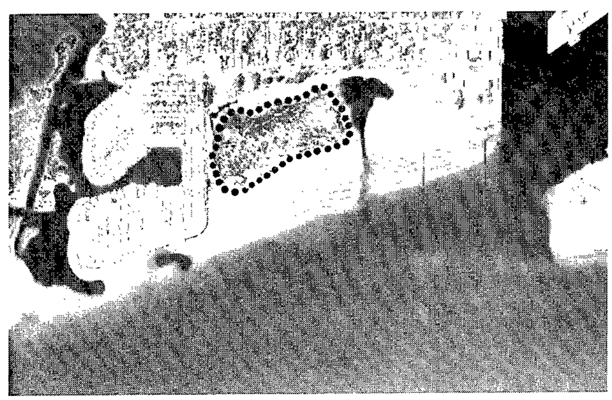


Figure 49. Aerial photograph (1962) showing Lassing Park borrow area, access channel, and adjacent seagrass beds (enclosed in dotted lines).

in the hole at Lassing Park, emergency permits were granted by the regulatory agencies to the City of St. Petersburg to fill the hole. The project, using 34,846 m^3 of uncompacted material from the Bayboro Channel area to the north, was completed on 21 August 1983. In September, however, George F. Young, Inc., consultants to the City, determined that 1,154 m^3 of that material was "soft, gray-black sediment" of "mucky" consistency unsuitable and unsafe for fill. In early 1984 the material was removed and the area refilled.

The original filling was done by Hendry Dredging Company for $188,000. The cleanup of the "mucky" sediment was done by Interbay Marine Construction for $55,000.

c. Monitoring data. Monitoring of the fill sediment has been mentioned in the previous section. No formal monitoring of seagrass establishment has been done. The area was documented as devoid of seagrasses in a 13 March 1984 Biological and Water Quality Assessment by L. Devroe of the FDER.

d. Field assessment. Continental Shelf Associates, Inc. (CSA) scientists visited the Lassing Park site on 28 November 1984 at 1300 h (low tide) approximately 1.25 years after the initial fill project. The fill area was a shallow (water depth of approximately 1 m), fine sand bottom behind a very shallow shoal approximately 180 m from the shoreline. The area designated as the silt and clay deposit was deeper (water depth of 1.2 m) and had a softer bottom than the surrounding fill area.

The bottom was investigated along a series of three transects originating from shore to the shoal area, approximately 180 m from shore (Figure 50). Transects 1 and 2 contained no seagrasses, but small patches of benthic algae and onuphid polychaete tubes were seen. The lightly chitonized mucus and detritus tubes, extending approximately 2.5 cm above the sediment, were present along the transects. Transect 3 had a bare sand bottom from shore to 152 m. A large seagrass bed to the south extended into the study area, covering Transect 3 from 152 m to its end, 180 m from shore.

The only organisms observed in the project area were the polychaetes and several *Dasyatis sayi* (bluntnose stingray).

e. Evaluation. The potential for seagrass establishment in the filled area is high. Seed and vegetative growth sources exist immediately south of the site. Reworking of the sediment by benthic organisms and colonization by benthic algae often precedes seagrass establishment. Diverse and dense fish and invertebrate communities typical of seagrass beds are found in the 9.6-ha seagrass area south of the fill site. The FDNR intends to use this area for experimental seagrass plantings (K. Haddad, FDNR; pers. comm., 1984,). However, increased use of this area by bathers now that the area has been made "safer" by filling could be in conflict with seagrass establishment.

This project demonstrates that dredged material can successfully be used to fill unused channels and borrow pits. The quality of the fill, however, should be carefully considered.

1.4 SUMMARY AND RECOMMENDATIONS

1.4.1 Summary

Ten sites where restoration was to have occurred were evaluated. These included filling of a subtidal area and plantings of black needlerush (*Juncus roemerianus*), mangroves (*Rhizophora mangle*, *Avicennia germinans*, and *Laguncularia racemosa*), and smooth cordgrass (*Spartina alterniflora*). Two of the sites were plantings on dredge-spoil islands. Specific goals were not stated for most of these projects. Our criteria for success must therefore be defined after the fact, and may not be the same as those envisioned by the contractor or regulatory agency. It is unlikely that a particular restoration project could meet all possible criteria for success, such as increasing productivity, providing habitat for particular species, controlling erosion, and improving water quality. Without studies of conditions existing

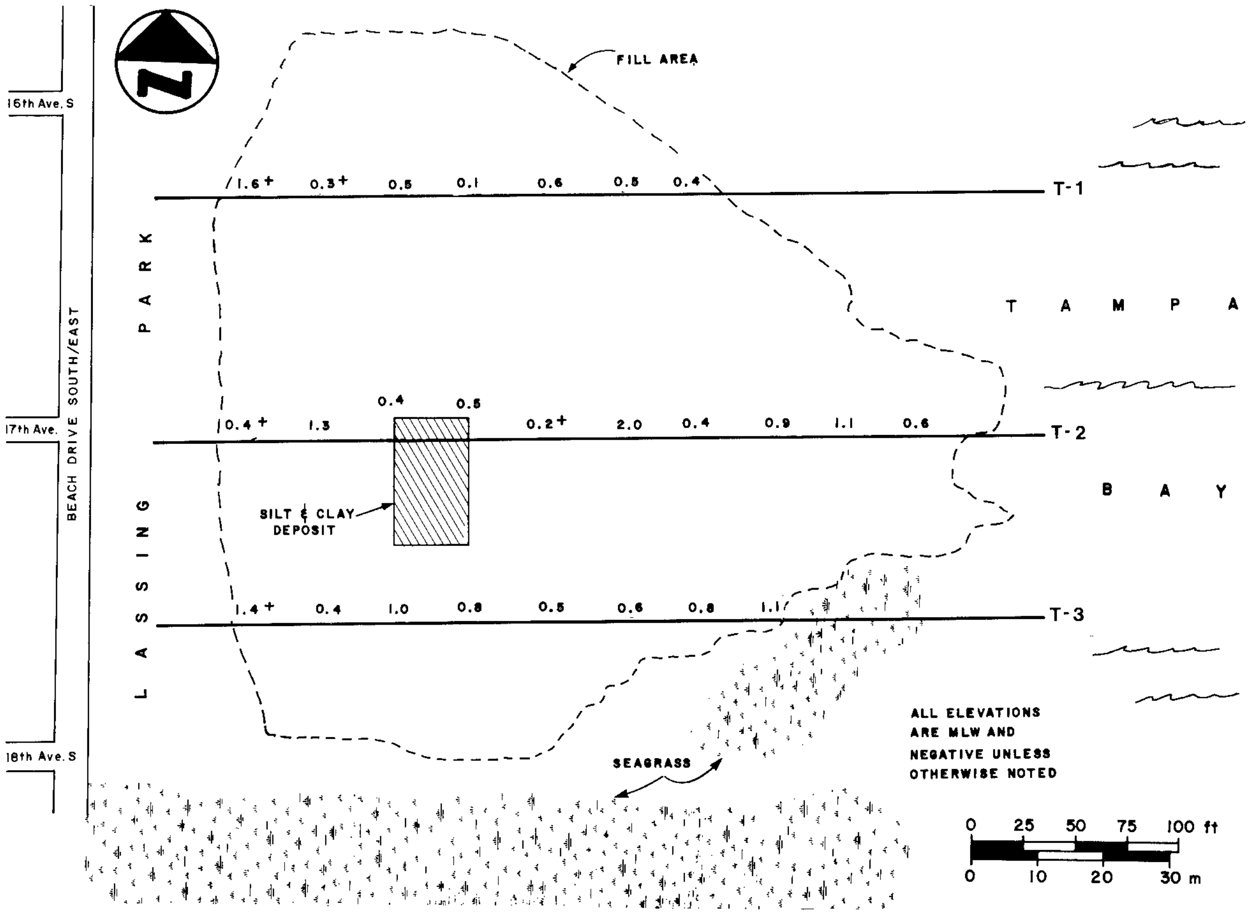


Figure 50. Diagram of the Lassing Park site depicting fill areas, silt deposit, 28 November 1984 field assessment transects (T-1 through T-3), and adjacent seagrass beds (from survey by George F. Young, Inc. 1983).

before the projects and a knowledge of natural population variability, it is difficult to evaluate habitat replacement--which is the goal usually suggested or implied for restoration projects.

Success can be defined in terms of plant survival of the species planted and how this provides for in-kind replacement of the plant species lost. However, even these criteria pose difficulties in defining success unless: (1) the previously existing natural densities for the sites evaluated are known, (2) a desired density is defined, and (3) specific goals for that density are delineated. For the sites investigated, a variety of plants with different growth rates were planted. The lengths of time since planting and the environmental conditions where the plantings occurred varied and may not have been optimal for the species planted.

Spartina alterniflora was planted at six sites from 6 months to 6 years before this study. For five sites, data concerning survival at 1 year after planting are available (Table 18). Three sites (Archie Creek, Sunken Island, and Placido Bayou) had 70%+ survival, whereas two sites (Palm River and Feather Cove 1984) had survival rates of 25% or less. The portion of Feather Cove planted in 1983 had 90% survivorship. Shoreline erosion has destroyed a large portion of the S. alterniflora planted at Spoil Island 2-D. Four sites were older than 5 years at the time of the evaluation.

Table 18. Summary of information on selected mitigation/restoration projects in Tampa Bay.

Habitat type called for in restoration	Project name	Reasons for restoration	Time of restoration	Size of planted plot (ha)	Wetland habitat loss (ha)	Permanent loss (ha)	Survival after 1 yr %	Average density (at time of study) per m^2
Spartina	Archie Creek	Mitigation	1978	1.82	1.5	0	75	230
	Sunken Island	Habitat enhancement	1978	1.64	NA.[a]	NA.[a]	93.4	102
	Feather Cove	Enforced mitigation	1983 and 1984	0.6 2.5	4	b	90 <10	163 0
	Placido Bayou	Mitigation	1983	1.0	1.0	b	70	31
Mangrove and *Spartina*	Palm River	Erosion mitigation	1979	0.012	Unknown	c	19	ND
	Fantasy Island and Spoil Island and 2-D	Mitigation	1979 and 1981	2.12	2.1	c	73.3[d]	3[d] 110[f]
Mangrove	Apollo Beach	Enforced mitigation	1974	1.6	110+	b	<10	10-17
	Harbor Island	Enforced mitigation	1974	10	10	b	<10	0
Juncus marsh	Branches Hammock	Mitigation	1980	2.32	2.86	1.9	50[e]	ND
Subtidal fill	Lassing Park	Safety	1983	3.9	NA.[a]	NA.[a]	NA.[a]	NA.[a]

[a] Not applicable.
[b] Cannot be determined with existing data.
[c] Permanent losses occurred, but area cannot be determined with existing data.
[d] % mangroves only.
[e] % survival after 22 months.
[f] *Spartina* only

Spartina alterniflora has been reported to coalesce in less than two years when planted at 0.3 m intervals (Kruczynski 1982). Density values averaged greater than 100 culms/m^2 at the 6 year old projects (Archie Creek and Sunken Island). However, variability in planting success after 1 year is shown by the successful portion of Feather Cove (approximately 150 culms/m^2) and Placido Bayou (an average of less than 50 culms/m^2). Lewis and Lewis (1977) reported 741% (36 to 267 culms/m^2) increases in plant density values after 10 months on Fishhook Spoil in Tampa Bay. In Georgia, density values for S. alterniflora increased 977% (10 to 97.7 culms/m^2) after 5 months (Reimold 1980). This evaluation shows that excellent growth for S. alterniflora can be achieved in Tampa Bay given the proper conditions. Factors contributing to poor survival include: failure to restore the habitat to appropriate elevations; shoreline erosion; poor maintenance (i.e., removal of exotic vegetation, floating debris, etc.); competition by high marsh or upland plants; and poor planting technique.

Spartina alterniflora was established successfully in areas of low tidal and wave energy (Archie Creek, Sunken Island, a portion of Feather Cove, and Placido Bayou), but not in areas undergoing erosion (Spoil Island 2-D and Palm River). A contributing factor may be the lack of sufficient root mass to bind the sediments and retard erosion. Cammen (1976) found that the aboveground biomass of S. alterniflora established on dredged spoil equaled that of a natural marsh but the belowground biomass was less than half that in a natural marsh. Therefore, S. alterniflora may not be a good choice for controlling shoreline erosion; structural methods might be considered in conjunction with marsh grass plantings.

Succession of S. alterniflora to mangroves is occurring at three sites (Archie Creek, Sunken Island, and Placido Bayou). Spartina alterniflora serves as a pioneer species for invasion by mangroves (Lewis and Dunstan 1976a; Lewis 1982b) and may be expected to decline as the mangroves increase in density and size. Invasion appears to occur within 1 to 5 years for all species of mangrove. The species invading varies depending upon the available seed source. All three species of mangroves had been naturally recruited among the planted S. alterniflora at Sunken Island. The heights of the trees ranged from 0.3 to 2.0 m.

At four sites, mangroves were planted 5 to 10 years before this study. At the two oldest sites (planted 9 and 10 years previously), the planted species (Rhizophora mangle) failed to grow (Harbor Island) or was the least abundant species (Apollo Beach), although reaching a height of 0.5 to 2 m at the latter site. Natural recruitment by white mangrove (Laguncularia racemosa) and black mangrove (Avicennia germinans) resulted in these species occurring in higher densities than red mangrove (Rhizophora mangle) at the latter site. Heights of these two species ranged from 0.5 to 3 m. Densities at the 5 year old site (Fantasy Island) averaged 3/m^2. Some of the planted individuals are being lost to erosion; however, natural recruitment is occurring rapidly enough to counter these losses. The trees at this site ranged in height from 0.3 to 1.9 m at the time of planting. Heights 4 years later ranged from 0.1 to 1.2 m. The lack of apparent growth may have been caused by disproportionate death of the larger planted trees; stunting of growth by freeze damage; or low growth rates from low nutrient conditions because of high organic export. Alternatively, the small size of the mangroves may reflect recruitment of new seeds. Factors contributing to poor survival of mangroves include erosion and failure to restore the habitat to appropriate elevations.

Only one Juncus roemerianus site (Branches Hammock) was evaluated. Some habitat was permanently lost under the bridges and to the bridge structure. Recovery of J. roemerianus appears to be slower than that of S. alterniflora, and the conditions for survival of the former are more exacting. A mixed community consisting of J. roemerianus and other wetland species resulted when the proper substrate was not replaced by the bridge contractor. The regulatory agency decided not to require replanting of J. roemerianus because the existing community was deemed acceptable wetland habitat (FDER, pers. comm.).

For the subtidal site (Lassing Park), the goal of reducing water depth was achieved. It remains to be seen whether seagrasses invade this area naturally or survive if they are transplanted.

Two of the projects evaluated were conducted at dredge spoil islands. One was devised to compensate for destruction of vegetated intertidal habitat, whereas the other was a habitat enhancement project. The loss of bay bottom to these islands does not appear to have been considered in the overall balance of gains and losses. Given the extent of the seagrass losses in Tampa Bay, the creation of upland and vegetated intertidal habitat on the bay bottom may be inappropriate policy.

Permanent loss of wetland habitat has occurred in at least three projects (Table 18). Changes in the kind of plant species, for part or all of the area lost, have occurred in seven of the nine projects (the subtidal fill, Lassing Park, is not included). Archie Creek and Apollo Beach are the two sites which appear to have species of plants similar to those occurring in the lost habitats. Recovery of a community similar in function to that which was lost was not determined in this study, and is difficult to assess without measurements made before the previous community was lost.

The seven projects designed to mitigate for habitat lost required a 1:1 habitat replacement. Few projects, if any, achieved this goal if we assume in-kind replacement was the objective. For the six small mitigation projects plus one for erosion control, 20.4 ha of vegetated habitat were to be replaced (Tables 3 and 18); 1.9 ha of this may be permanently lost; and at least 18.3 ha of wetlands were replaced by a different kind of habitat than that lost (in-kind loss). Mangrove habitat has been replaced out-of-kind because it has been recommended that S. alterniflora be planted initially with the expectation that mangroves eventually will colonize planted areas. The remaining out-of-kind replacement projects which failed resulted in the creation of approximately 10 ha of unvegetated, shallow, subtidal bottom. In the one large project, Apollo Beach, 110 ha of mangrove forest were destroyed. Natural recruitment has resulted in a dense mangrove forest 13 years after destruction, but from aerial photography the area appears less well developed than an adjacent undisturbed mangrove forest.

Projects which involved only planting of vegetation ranged in cost from $2,324 to $17,447 per ha in 1985 dollars. Due to difficulties in isolating costs for site preparation, planting, monitoring, etc., little useful information can be obtained beyond acknowledgement of the inflationary influences on restoration projects. Current cost quotes for restoration projects are based upon a unit cost per planted ha. This varies with species planted and project size. Cost per planted ha currently averages $20,000 to $40,000 for mangroves (nursery grown 4-inch pot) and $10,000 to $15,000 for S. alterniflora transplanted plugs. Comparison of present day costs/ha to the reviewed project costs indicates that prices have not changed drastically in the last decade; in some instances, they have declined due to refined growing techniques. Costs incurred in structural modifications and elevational changes are far in excess of actual planting costs and may be included in the total cost. Costs also vary depending upon whether plant species are transplanted or nursery-raised, what size plant is used, whether the site is accessible, and other factors.

1.4.2 Recommendations

Human construction of wetland habitats is difficult and should be attempted only after all other avenues have been explored. It is better to avoid or minimize development impacts during the planning stage than to redress or compensate for them later. If impact avoidance is not possible, in-kind replacement of the habitat is recommended. Replacement by an alternate habitat should be considered only if the replacement habitat has been determined to be rare and endangered and the habitat lost is relatively common. Restoration for lost habitat should occur in upland areas, if possible, so that wetland area is maintained at a constant level. Enhancement of existing wetland is

desirable to mitigate for impacts that degrade but do not destroy wetlands.

Additional compensation by replacing more area than that lost should be required if the probability of successful replacement of a habitat type is low, as with seagrasses, or if the length of time for recovery is longer than two growing seasons, as when Spartina alterniflora is planted to replace mangroves. Although this species is recommended for planting instead of mangroves, the succession to a mature mangrove forest requires many years. During the successional period, the many functions of mangrove forests, including provision of breeding habitats for wading birds and pelicans (Schreiber and Schreiber 1978) would not be realized.

Our site surveys were primarily vegetation surveys. Although we recorded observations of fish and wildlife, November is not a time when use by birds or fishes is very high. Quantitative observations during different seasons and knowledge of fish and wildlife usage of comparable natural habitats are necessary for a complete evaluation of the success of the restoration projects.

Monitoring to determine that restored habitat is functioning well for its stated goals and maintenance to control damage by floating debris and invasion by exotic plants should be included in the design of future projects. Documentation and publication of the results should be required so that this information is available for future projects.

Future mitigation/restoration projects in wetlands may be more successful if specific goals for the area being restored are stated, compliance is more strictly enforced, and restoration techniques are refined to meet the goals. A detailed mitigation policy must be developed. Assurity bonds should be required prior to issuing permits.

Detailed mitigation policy has yet to be developed by the State of Florida, though it is expected in the near future as the Warren S. Henderson Wetland Protection Act of 1984 is implemented. Monitoring and enforcement are increasing as agencies gain authority to protect these habitats.

CHAPTER 2. FEASIBILITY OF MITIGATION OPTIONS IN SOUTH FLORIDA

2.1 TECHNICAL APPROACH

Feasibility of various mitigation/restoration options was analyzed for several habitat types (mangrove, salt marsh, seagrass, etc.) by reviewing projects that have been conducted in South Florida. The projects selected represent mitigation options identified by the U.S. Fish and Wildlife Service (USFWS) workshop participants (Auble et al. 1985) as measures to compensate for unavoidable impacts. Measures identified in the workshop as those that reduce adverse impacts of development actions were not addressed. These measures need to be addressed at the planning stage and represent good resource management; however, criticism of the port development actions is not the purpose of this document.

2.1.1 Selection of Projects

Project selection criteria were:

1) to select projects that are most applicable to mitigation options that are feasible in Tampa Bay;
2) to select several projects for each habitat type to demonstrate various mitigation options; and
3) to select projects that demonstrate the importance of factors such as project cost, life-span, maintenance, and public acceptance, if this information is available.

The geographic scope of our study was restricted by item (1) above, as not all mitigation projects in South Florida are applicable to Tampa Bay. The bay is near the northern limit for mangrove growth on the west coast of Florida; consequently, mangroves dominate the shoreline, but are susceptible to freeze damage. Salt marsh vegetation occurs primarily as an early successional stage in marginal or newly created habitats in Tampa Bay rather than as the extensive salt marshes common farther north, on both the west and east coasts of Florida. Therefore, we restricted our attention to projects conducted no farther north than Tampa Bay on the west coast, and the Indian River on the east coast. Projects conducted farther north, especially the early salt marsh restoration work in marshes of the mid-Atlantic or northern Gulf of Mexico coasts, were not selected for review, even though pertinent details are discussed below, as appropriate. Likewise, the environment of the Florida Keys, where several experimental seagrass plantings have been attempted, differs from that of Tampa Bay. Therefore, projects conducted in the Keys were not selected for evaluation, although they are cited for information where needed.

Additional projects were added to the list through discussions and meetings with staff from the various agencies involved in environmental permitting: USFWS, National Marine Fisheries Service (NMFS), Tallahassee and district offices of the Florida Department of Environmental Regulation (FDER), U.S. Army Corps of Engineers (USACE), Florida Department of Transportation (FDOT), Florida Department of Natural Resources (FDNR), and Dade County Evironmental Resources Management (DERM). Information was also obtained from companies involved in designing and planting wetlands mitigation projects, including Coastal Revegetation, Inc.; Mangrove Systems, Inc.; Applied Marine Ecological Services, Inc.; and Tropical BioIndustries, Inc. Proceedings of the annual restoration conference held in Tampa, which include information on major

restoration projects in the southeastern United States, were also used to identify projects for review. Projects were selected from these sources on the basis of the criteria stated above.

2.1.2 Data Identification and Acquisition

Historical data on mitigation/restoration projects in South Florida were acquired from local, State, and Federal agencies, individuals, and organizations (Table 19). Collected information included habitat type; success/failure of the project; cost of the project; expected life-span; monitoring or maintenance records; firm, agency, or individual implementing the project; and any information available concerning public acceptance of the project.

Table 19. List of contacts made for source information on mitigation/restoration projects in South Florida.

Agency	Location	Contact(s)
Florida Department of Environmental Regulation	Punta Gorda, FL	Richard Cantrell
	West Palm Beach, FL	Larry O'Donnell
	Tampa, Fla	Bill Kutash Allan Hooker Larry Devroe
	Port St. Lucie, FL	Robert Brown Mike Nagy
	Tallahassee, FL	Fred Calder Andy Feinstein Suzanne Walker Joe Ryan Scott McClelland Mark Latch Beverly Birkitt
Florida Department of Natural Resources	St. Petersburg, Fl	Ken Haddad Alan Huff Karen Steidinger Mike Durako Barbara Harris
Florida Department of Transportation	Bartow, FL	Wendy Geisy
Mangrove Systems, Inc.	Tampa, FL Miami, FL	Robin Lewis Steve Lumbert
Martel Laboratories, Inc.	St. Petersburg, FL	Tom Kunneke Keith Patterson

(continued)

Table 19. (Concluded).

Agency	Location	Contact(s)
National Marine Fisheries Service	Panama City, FL	Ed Kepner David Nixon
	St. Petersburg, FL	Andy Major
General Development Corporation	Miami, FL	Wes Jurgens
University of Miami	Miami, FL	Howard Teas
Tampa Port Authority	Tampa, FL	Bill Fehring
U.S. Army Corps of Engineers	Jacksonville, FL	Lloyd Saunders
U.S. Fish and Wildlife Service		
	Atlanta, GA	Jim Brown
	Panama City, FL	Lorna Sicarello Jim Barkuloo
	Slidell, LA	Jim Johnston Larry Shanks Millicent Quammen
	Vero Beach, FL	Joe Carroll Arnold Banner Bob Turner
Dade County Environmental Resources Management, Inc.	Miami, FL	Jeffry Marcus David Ettman Kevin Mayo
Sarasota County	Sarasota, FL	Steve Sauer
Consulting Engineer	Riviera Beach, FL	Gerald M. Ward
Tropical BioIndustries	Miami, FL	Durban Tabb Eric Heald
Coastal Revegetation, Inc.	Delray Beach, FL	Pam Reeder
Applied Marine Ecological Services, Inc.	Miami, FL	Anitra Thorhaug

Identifying all available published and other unpublished scientific literature on habitat mitigation/restoration required a computer search of several major data bases. Pertinent documents or publications were then obtained from authors, agencies, or academic institutions.

2.2 REVIEW AND EVALUATION OF MITIGATION OPTIONS IN VARIOUS SOUTH FLORIDA HABITATS

Tampa Bay is not unique in having experienced a decline in acreage of wetlands and other valuable coastal habitats; most of South Florida has experienced similar declines as a result of increasing development. The results of mitigation and restoration projects that have been conducted elsewhere in South Florida will add to our understanding of factors to be considered in developing an overall mitigation strategy for Tampa Bay. This section reviews mitigation projects for various South Florida habitat types (salt marsh, mangrove, seagrass, mud flat, artificial reef, and oyster reef).

Although most mitigation/restoration projects typically have involved revegetation of an existing habitat, planting on habitats produced from dredge spoil has special concerns. Because of the body of literature concerning dredged material restoration projects and the pertinence of this option to the situation in Tampa Bay (where large quantities of dredged material have been and will continue to be produced), dredged material projects are evaluated below in a separate subsection (Section 2.3).

As noted previously, the geographic scope of our project selection process encompassed South Florida exclusive of the Florida Keys. In the discussions below, pertinent information from projects conducted outside the study area is cited as introductory material in each subsection.

2.2.1 Salt Marsh Habitats

Salt marshes are herbaceous plant communities in the intertidal zone of estuaries (Kruczynski 1982). In Florida, salt marshes are found north of Daytona Beach along the east coast, and north of Tarpon Springs along the west coast and panhandle. Farther south, mangrove communities predominate, and marsh plants are typically pioneers in marginal or newly formed habitats. Common marsh species in Florida are *Spartina alterniflora* (smooth cordgrass), which is found between mean sea level and mean high tide level (low marsh); and *Juncus roemerianus* (black needlerush), which is found above the mean high tide level (high marsh) and in areas of lower salinity. Other grasses, such as *Distichlis spicata* and *Paspalum vaginatum*, and succulents, such as *Batis maritima*, *Salicornia virginica*, and *Sesuvium portulacastrum*, are also found in the high marsh.

The value of salt marshes as nursery grounds and/or a source of energy for sport and commercial fishery species is well documented (Odum 1961; Teal 1962; Williams and Murdock 1969; Turner 1978; Rogers et al. 1984). This relationship has been found to be particularly important in the Gulf of Mexico where the majority of commercial fish landings are estuarine dependent (Nixon 1980). Early studies asserted that salt marshes store and recycle nutrients between the sediments and surrounding water (Pomeroy et al. 1967; Williams and Murdock 1969), but evidence to substantiate this was inconclusive and varied among salt marshes sampled (Nixon 1980). Evidence exists that some salt marshes may: (1) export organic carbon; (2) be sinks for many trace metals, including lead, copper, zinc, iron, and manganese; (3) act as nitrogen transformers; and (4) be sinks for total phosphorus. These functions vary with the location and size of the marsh and the amount of open water adjacent to the marsh (Nixon 1980). Variability of function probably exists between the salt marshes of the various basins and bays of Tampa Bay. Salt marshes have been found to stabilize shorelines by absorbing and dissipating wave energy (Garbisch et al. 1975).

a. Techniques and early experiments: Woodhouse and Knutson (1982) compiled knowledge gained from previous studies and summarized planting techniques and guidelines for common salt marsh vegetation. The following techniques have

been used to plant the salt marsh vegetation found in Florida (Woodhouse 1979; Woodhouse and Knutson 1982):

1) seeds planted 1 to 3 cm deep in the upper 20% to 30% of the tidal range;
2) sprigs or culms, intact single stem plants taken from nursery grown plants or plugs, planted 10 to 15 cm deep in holes;
3) plugs or plants with sediment intact, taken from a natural stand and planted into a hole; and
4) nursery grown plants in peat pots planted in a hole.

Although the species studied exist in Florida, neither the planting of seeds nor their use for nursery growing has occurred extensively. Lewis (1982) stated that most seeds of *Spartina alterniflora* harvested in Florida to date are either sterile or damaged by insects.

Summaries by Woodhouse (1979) and Woodhouse and Knutson (1982) included estimated costs for shoreline preparation and protection; plant harvesting, processing, and planting; and plant fertilization, if required. The time spent planting the vegetative material using the most common methods was summarized by Woodhouse and Knutson (1982):

Method	Work hours/ 1,000 units
Sprigs	10
Nursery grown seedlings	23
Plugs	30

To estimate labor requirements for a particular project, one must first determine the number of planting units required as follows:

Number of Planting Units = Area of Planting x 1/(plant spacings)^2. Then, the labor required to prepare and plant these units must be determined as follows:

Labor required = Number of Planting Units x Work hours/1,000 units. A typical project using sprigs spaced 1.0 m apart will require 10,000 planting units and 100 work hours per ha (Woodhouse and Knutson 1982).

The USACE, through sponsorship by the Coastal Engineering Research Center (CERC), initiated studies on salt marsh building in 1969 in North Carolina to stabilize and protect dredge spoil on eroding shorelines (Woodhouse et al. 1974, 1976). These studies expanded to Chesapeake Bay (Garbisch et al. 1975) and the Gulf of Mexico coast (Dodd and Webb 1975; Webb and Dodd 1976). Studies conducted by the USACE Waterways Experiment Station during the Dredged Material Research Program utilizing salt marsh vegetation to stabilize dredged spoil will be discussed in Section 2.3.

b. Selected projects. Vero Beach, Indian River: The Indian River on the Atlantic coast of Florida is similar to Tampa Bay in that mangroves are dominant but *S. alterniflora* is also present, particularly on newly exposed sandy shores such as newly created spoil sites or dikes. Lewis and Dunstan (1976) examined *S. alterniflora* growth on spoil islands in the Indian River and Tampa Bay. Their observations suggested that the rapid-growing *S. alterniflora* stabilizes and prepares the substrate for colonization by mangroves.

This concept was recommended by the USFWS for a restoration effort (Banner 1977) located approximately 3.2 km north of Vero Beach. The project was the result of an enforcement action by the USACE under guidance of the USFWS (Banner 1977). The initial illegal activity involved the filling of a wetland slough that nearly bisected the property. The owner then built a bulkhead along the property and began excavating a channel waterward of the bulkhead. The USACE required that the owner fill the channel to the original shoreline contour. Coarse yellow sand mined locally was used as fill. An experimental restoration plan developed by the USFWS (Banner 1977) consisted of bands of *S. alterniflora* plugs and *Rhizophora mangle* plantings. Some of the *R. mangle* seedlings were planted within bands of *S. alterniflora*. Planting was done in May 1976, and, within 1 year, density of *S. alterniflora* had increased 2,595% and the plants had set seed. The *R. mangle* seedlings experienced only 24% survival overall and only 4% survival when planted with *S. alterniflora*. However, all three

species of mangroves had drifted into the area as seeds and had become established. The author validated the recommendation to plant S. alterniflora plugs in restored intertidal substrate within the Indian River as a means to prepare the substrate for future colonization by mangroves (Banner 1977).

Stuart and Jensen Beach Causeways, Indian River: The USACE selected Stuart and Jensen Beach Causeways as demonstration sites for use of wetland vegetation to control erosion (Smith 1981). The two sites are located between the St. Lucie and Ft. Pierce Inlets on the Indian River.

A 1,300 x 50 ft (396 x 15 m) area along the eastern island of each causeway was cleared of vegetation (predominantly Casuarina equisetifolia) and graded. Wetland vegetation selected for planting included R. mangle, Avicennia nitida (=germinans), Laguncularia racemosa, S. alterniflora, Spartina patens, and Paspalum vaginatum. Containerized nursery grown mangroves (30 cm tall) and P. vaginatum were used. Spartina alterniflora was planted as plugs and S. patens was planted as sprigs.

The areas were planted between 27 June and 20 July 1979. All plantings, except for the upper rows of P. vaginatum, were destroyed on 3 September 1979 by Hurricane "David." The areas were replanted in March 1980 using the same species. However, this time 60 cm tall mangroves were used and fertilizer was applied to the plantings.

At the Jensen Beach Causeway site, S. alterniflora showed vigorous growth within the intertidal zone after 2 months. Spartina patens and P. vaginatum planted above the high tide line also showed vigorous growth. Approximately 20% of the mangroves survived.

At the Stuart Causeway site, the eastern half of the planting eroded while the western half accreted. Spartina alterniflora grew through the accreting sand. Spartina patens and P. vaginatum planted above the high tide line showed vigorous growth, and approximately 18 months later, rows were no longer distinguishable.

The recommendation emerging from these and other studies performed under the Erosion Control Demonstration Act was to consider more often the use of wetland vegetation to stabilize shorelines. At times, however, wave breaks are also needed.

Other projects: Most of the S. alterniflora plantings in South Florida have been done to stabilize the sediment quickly and allow for eventual development of a mangrove community. This approach was used in the vegetation of approximately 16 km of complex canal system constructed for two residential housing developments off the Intracoastal Waterway south of Jupiter, Florida (Snyder et al. 1983). The shorelines of these canals were sculpted in an undulating pattern to increase intertidal area. A total of 650,000 S. alterniflora plugs were planted, and 250,000 R. mangle seedlings were interspersed among the S. alterniflora plantings. Variations in growth of S. alterniflora and all species of mangroves (L. racemosa and A. germinans had drifted in as seeds and had become established) have been observed. The variations can be attributed to: (1) variations in groundwater inflow, leading to invasion of freshwater species at elevations near mean high water (MHW); (2) variability in soil characteristics; and (3) shading of new growth by dead vegetation of the previous year (Snyder et al. 1983).

Several other planting projects of this type have been conducted, but no monitoring data are available on which to evaluate their success.

c. Evaluation. Spartina alterniflora is a quick-growing sediment stabilizer which traps mangrove seeds and protects mangrove seedlings through early growth (Lewis and Dunstan 1976), as shown in projects in Tampa Bay (e.g., Sunken Island, Chapter 1, Section 1.3.5), on the Indian River (e.g., Vero Beach), and in other locations in Florida. The mangroves eventually grow over the S. alterniflora and kill it by shading. The pioneering role of S. alterniflora in mangrove

wetland establishment in Florida was noted by Davis (1940); S. brasiliensis was noted as being a primary colonizer of mangrove wetland areas in British Guiana by Martyn (1934). Spartina alterniflora, because of its pioneering role, should be considered as the primary species to use for intertidal wetland revegetation projects in Tampa Bay; however, to compensate for the time lag in recovery of the mangrove habitat, a greater amount of area should be restored than was lost.

A number of factors are known to influence the success of salt marsh plantings (Woodhouse and Knutson 1982). Consideration of the natural tidal elevation range of the plant is the primary factor, and the reason for the failure of the S. alterniflora plantings at Feather Cove (see Chapter 1, Section 1.3.8) is they were planted below mean tide level for that area.

Soil type does not appear to be a primary factor for S. alterniflora plantings. At Archie Creek (see Chapter 1, Section 1.3.3), S. alterniflora was successfully planted on sand and anaerobic mud. Dredge spoil varies in grain size and sediment conditions; however, plantings of S. alterniflora, have been successful on a full range of grain sizes (see Sunken Island and Fantasy Island, Chapter 1, Sections 1.3.5 and 1.3.4 and Chapter 2, Section 2.3). Juncus roemerianus, as demonstrated at Branches Hammock (see Chapter 1, Section 1.3.7), seems more sensitive to soil type; however, failure of portions of this planting could have been due to tidal elevation (planting above the elevation range for J. roemerianus) or slow growth. Eleuterius and Caldwell (1981) document the very slow growth and coalescence of J. roemerianus.

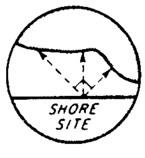
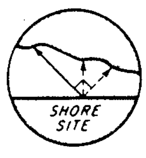
Stress due to salinity levels is a common factor affecting all salt marsh plantings. Some of the plants (e.g., S. alterniflora) have special structures for salt excretion. Salt accumulation, however, is a problem in irregularly flooded areas and may be one of the factors in development of salt barrens found at Apollo Beach (see Chapter 1, Section 1.3.6). Competition with freshwater vegetation is a problem in areas of decreasing salinity; the Palm River erosion control project (see Chapter 1, Section 1.3.2) was near the lower limits of salinity for growth of S. alterniflora within the Tampa Bay estuary.

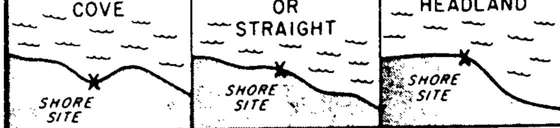
Wave climate is a consideration in success of salt marsh plantings. Wave climate severity affected the spoil island projects within Tampa Bay. The planting at Fantasy Island (see Chapter 1, Section 1.3.4) experienced limited survival because of erosion and berm-building by wave energy on the island. The planting at Sunken Island (see Chapter 1, Section 1.3.5), however, was successful because it was protected from wave energy. Knutson et al. (1981) developed a form for evaluating wave climate based upon observed relationships between fetch, shore configuration, and grain size and success in controlling erosion in 86 salt marsh plantings in 12 coastal states (Figure 51).

2.2.2 Mangrove Habitats

Mangroves are an important resource in coastal South Florida. They protect shorelines, contribute detritus to estuarine food webs, and provide habitat for a variety of animals, including commercially important fishes and wildlife (Teas 1977; Odum et al. 1982). Three mangrove species are found in Florida: Rhizophora mangle (red mangrove), Avicennia germinans (black mangrove), and Laguncularia racemosa (white mangrove). Rhizophora mangle and L. racemosa have been reported as far north as Cedar Key on the west coast of Florida (Rehm 1976), and north of Ponce de Leon Inlet on the east coast; these northern extremes lie at approximately 29°10'N Lat (Teas 1977) (Figure 52). Avicennia germinans has been found as far north as 30°N Lat on the east coast (Savage 1972) and it also occurs as scattered shrubs along the islands of the Gulf Coast States to Mexico (Odum et al. 1982).

a. Techniques and early experiments. Table 20 is a chronological listing of most of the recorded mangrove planting attempts in Florida. Many of these projects were small and experimental;

1. SHORE CHARACTERISTICS	2. DESCRIPTIVE CATEGORIES (SCORE WEIGHTED BY PERCENT SUCCESSFUL)				3. WEIGHTED SCORE
a. FETCH-AVERAGE AVERAGE DISTANCE IN KILOMETERS (MILES) OF OPEN WATER MEASURED PERPENDICULAR TO THE SHORE AND 45° EITHER SIDE OF PERPENDICULAR 	LESS THAN 1.0 (0.6)	1.1 (0.7) to 3.0 (1.9)	3.1 (1.9) to 9.0 (5.6)	GREATER THAN 9.0 (5.6)	
	(87)	(66)	(44)	(37)	
b. FETCH-LONGEST LONGEST DISTANCE IN KILOMETERS (MILES) OF OPEN WATER MEASURED PERPENDICULAR TO THE SHORE OR 45° EITHER SIDE OF PERPENDICULAR 	LESS THAN 2.0 (1.2)	2.1 (1.3) to 6.0 (3.7)	6.1 (3.8) to 18.0 (11.2)	GREATER THAN 18.0 (11.2)	
	(89)	(67)	(41)	(17)	
c. SHORELINE GEOMETRY GENERAL SHAPE OF THE SHORELINE AT THE POINT OF INTEREST PLUS 200 METERS (660 FT) ON EITHER SIDE	COVE	MEANDER OR STRAIGHT	HEADLAND		
	(85)	(62)	(50)		
d. SEDIMENT GRAIN SIZE OF SEDIMENTS IN SWASH ZONE (mm)	less than 0.4	0.4 – 0.8	greater than 0.8		
	(84)	(41)	(18)		
4. CUMULATIVE SCORE					



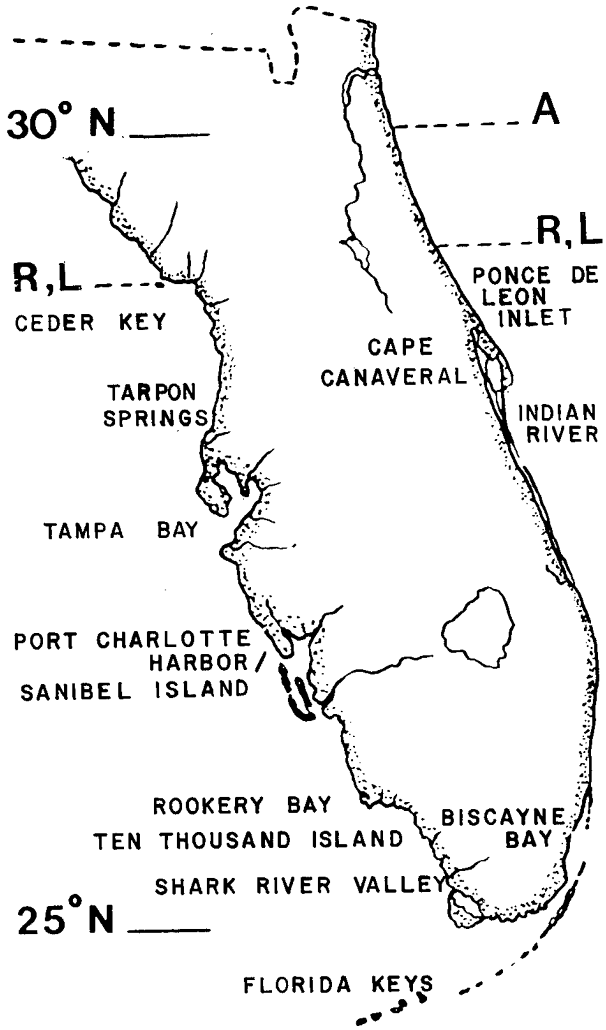
5. SCORE INTERPRETATION			
a. CUMULATIVE SCORE	122 – 200	201 – 300	300 – 345
b. POTENTIAL SUCCESS RATE	0 to 30%	30 to 80%	80 to 100%

Figure 51. Form for evaluating the effect of wave climate on a potential salt marsh planting site (from Knutsen and Woodhouse 1983).

several, however, were initiated to mitigate environmental damage.

The first reported R. mangle planting was performed to prevent shoreline erosion along the Florida Overseas Railway in the Florida Keys (Bowman 1917). Savage (1972) investigated the biology and use of each mangrove species as shoreline stabilizers in several experimental plantings within Tampa and Sarasota Bays. Avicennia germinans was found to be at least as important as R. mangle as a shoreline protector and, due to wide tolerances of A. germinans to climate and soil conditions, often a better choice than R. mangle for planting projects.

Mangroves have been planted in various forms from seed to mature plant. The seed, or propagule in the case of R. mangle, can be planted on site or can



NOTE: (BASED ON SAVAGE 1972): ALTHOUGH NOT INDICATED IN THE FIGURE, THE A. GERMINANS EXTENDS ALONG THE NORTHERN GULF OF MEXICO AS SCATTERED SHRUBS.

Figure 52. Approximate northern limits for *Rhizophora mangle* (R), *Avicennia germinans* (A), and *Laguncularia racemosa* (L), in Florida (from Odum et al. 1982).

be nursery grown to seedling or tree. Seedlings or trees can also be transplanted from natural stands. Cost of the revegetation project usually depends upon planting type and spacing. The price of the project has been shown (Lewis 1982b) to increase directly with the size of the plant, and inversely with spacing of the plantings. Planting success typically increases with increasing plant size, but results are variable; attempts to plant large trees have been unsuccessful (e.g., Teas 1977).

b. Selected projects. Grassy Point, Peace River, and Port St. Lucie, St. Lucie River. General Development Corporation attempted planting *R. mangle* at four sites in South Florida (Teas et al. 1975): Grassy Point on the Peace River in Charlotte County to restore a tidal creek; and three locations along the St. Lucie River in Port St. Lucie, St. Lucie County, to stabilize canal banks (Figure 53).

Grassy Point originally supported a fringing community of *R. mangle* along a meandering tidal creek; upland areas were dominated by *A. germinans* and *L. racemosa*. Grassy Point is a low-energy environment, isolated from boat traffic and urban influences. During development for housing, strips of natural wetland vegetation were left between the canal and spoil areas. Restoration of the site began in 1974 by grading the site to contours from a 1957 survey and excavating the tidal creek. From analysis of aerial photographs, 2.2 ha were designated for replanting with 60,000 *R. mangle* propagules. The planting was monitored for 1 year, at which time 80% to 90% of the plantings had survived (Teas et al. 1975).

The three plantings on the north fork of the St. Lucie River provide an example of attempts to stabilize shorelines with native vegetation rather than vertical seawalls. The three sites--Coral Reef Waterway, Elkcam Waterway, and Canal B-19--were constructed to provide boating access and drainage from areas within Port St. Lucie to the north fork of the St. Lucie River. The Coral Reef Waterway site was steep [slope 1.5:1 (H:V)] and susceptible to high wave energy from boat traffic and wind. One hundred and seventy-eight *R. mangle* seedlings were planted in pockets of sand and mud along this shoreline. After 7 months, none of the plants survived. The Elkcam Waterway site was in a sheltered area connected to the north fork of the river; boat traffic and wind/wave energy, therefore, were moderate to low. The banks were sloped at 6:1 (H:V) and composed of sand. Four hundred and fifty *R. mangle* propagules and seedlings were planted within a jute fiber

Table 20. Attempted plantings of mangroves in Florida in approximate chronological order (Adapted from Lewis 1982b).

Location	Species	Date	Comments	Percent survival	Reference(s)
Florida Keys	*Rhizophora mangle*	1915-16	Erosion control	no data	Bowman 1917
Jewfish Creek	*R. mangle* *Avicennia germinans* *Laguncularia racemosa*	1938	Experimental transplants	4 (9 mo)	Davis 1940
Tampa and Sarasota Bays	*R. mangle* *A. germinans* *L. racemosa*	1969-71	Experimental planting and transplants	no data	Savage 1972
Tampa Bay	*R. mangle* *A. germinans* *L. racemosa*	1973	40 individuals of each species transplanted	100	Pulver 1976
Marco Island[a]	*R. mangle* *A. germinans* *L. racemosa*	1973	2,447 transplants on dredged spoil	16	Kinch 1981
St. Lucie Inlet	*R. mangle*	1975	Transplants (4- to 6-yr old trees)	65 - 85	Hannan 1976
Charlotte County Grassy Point[a]	*R. mangle*	1975	60,000 propagules	85 - 90	Teas et al. 1975
St. Lucie County[a]	*R. mangle*	1975	2,628 propagules and seedlings	0 - 90	Teas et al. 1975
Siesta Key	*L. racemosa*	1976	Transplants	100	Evans 1978
Miami	*L. racemosa* *A. germinans*	Mid-1970s	14 trees to 6 m height	0	Teas 1977
Tampa Bay	*R. mangle*	1975	Experimental	no data	Lewis and Dunstan 1976
Key West	*R. mangle*	1977	Propagules and seedlings 2- to 3-yr old transplants	45 98	Goforth and Thomas 1980
Miami	*R. mangle*	1977	Experimental aerial planting	no data	Teas and Jurgens 1979
Tampa Bay	*A. germinans* *L. racemosa*	1979	1,513 transplants	73.3 (13 mo)	Hoffman and Rogers 1981

(continued)

Table 20. (Concluded).

Location	Species	Date	Comments	Percent survival	Reference(s)
Naples Windstar[a]	R. mangle	1982	70,000 propagules	97 (6 mo)	Stephen 1983
Highland Beach	R. mangle	1981-82	1,350 seedlings	80 +	Reeder, pers. comm.
Boca Raton	R. mangle	1981	4,468 seedlings and transplants	92	Reeder, pers. comm.

[a]Discussed in text.

mat anchored with metal pins. After 4 months, 24% of the plants survived. The Canal B-19 site was a low-energy environment. The canal bank consisted of organic mud and had a gradual [10:1 (H:V)] slope. This site was planted with 2,000 R. mangle seedlings. After 4 years, it was estimated that 90% of the plants survived and some of the plants had flowered and fruited (Teas et al. 1975).

The monitoring study showed major factors affecting survival of mangrove plantings were, in order of importance, exposure to waves (both from wind and boat wakes) and human interference. Variation in substrates did not appear to be a factor in plant survival.

Windstar Project, Naples Bay: The Windstar Project, located on the east side of Naples Bay (Stephen 1983) involved the loss of mangrove and subtidal habitat. As mitigation, the developer offered to remove a series of spoil mounds within a 40-ha mangrove preserve on the property (Figure 54). The mounds had been created during the dredging of a navigation channel in Naples Bay. Removal of the mounds to intertidal elevations was proposed to create 6 ha of potential mangrove planting area.

Stephen (1983) described the construction of access roads to the spoil mounds and removal of the spoil material to a final elevation of +45 cm National Geodetic Vertical Datum (NGVD). The areas were planted in August 1982 with R. mangle propagules bundled in pairs to increase survival rate (Stephen 1983).

A survival rate of 97% was estimated 6 months after planting. Figure 55 shows the height, at 6 months, of randomly selected mangroves in relation to ground elevation. This demonstrates that tallest plants occurred at elevations slightly below the project design elevation (approximately +36 to +45 cm NGVD). The project design elevation was established to coincide with elevations of the surrounding mangrove marsh in accordance with a technique suggested by Lewis (1982b).

It was also noted that during monitoring (Stephen 1983) the construction tolerance of +15 cm to grade created low areas of ponded water which provided habitat for oysters and fishes (Figure 55). Areas higher than grade provided sites for colonization by A. germinans (Figure 55). Stephen (1983) reported that the variety of habitats created encouraged fish and wildlife development.

Total cost of the mitigation project was $250,000. The 64,000 yd^3 of removed spoil was used as upland fill for the development project. At a cost of $3.90/yd^3, this fill was estimated to be less than the cost to transport fill to the development site.

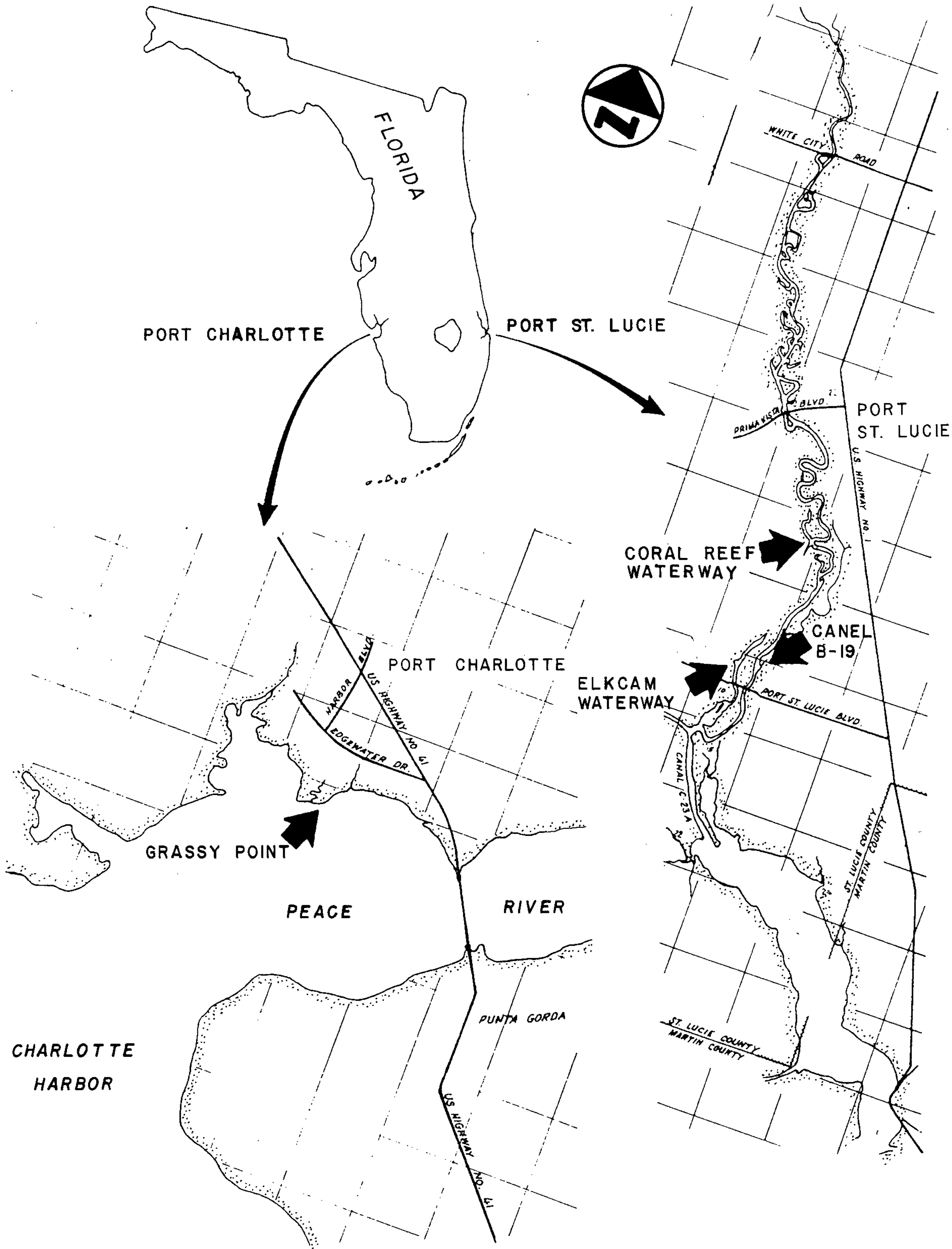


Figure 53. Locations of Rhizophora mangle planting at Grassy Point, Peace River, and Port St. Lucie, St. Lucie River (from Teas et al. 1975).

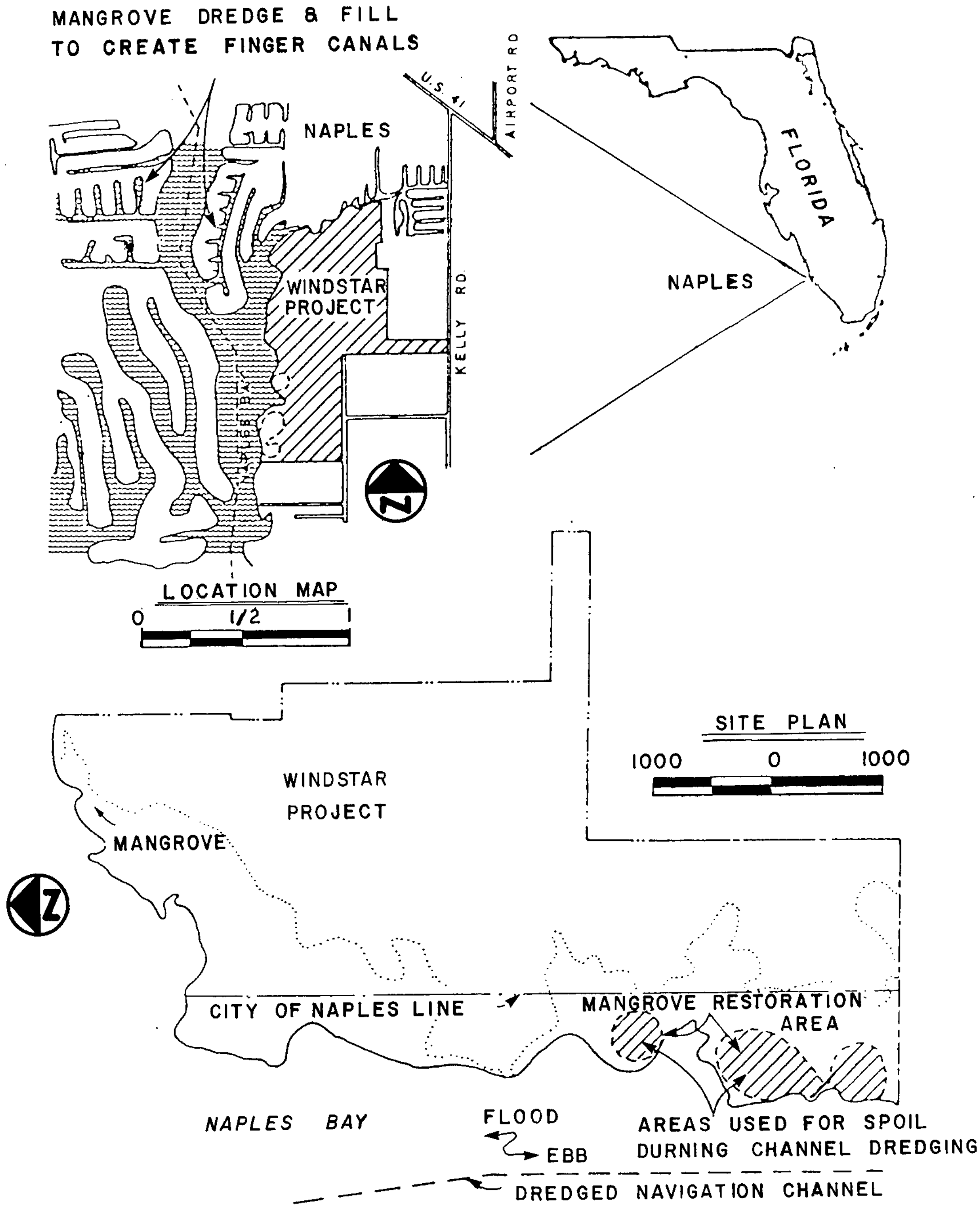


Figure 54. Location of the Windstar Project in Naples Bay near Naples, Florida (From Stephen 1983).

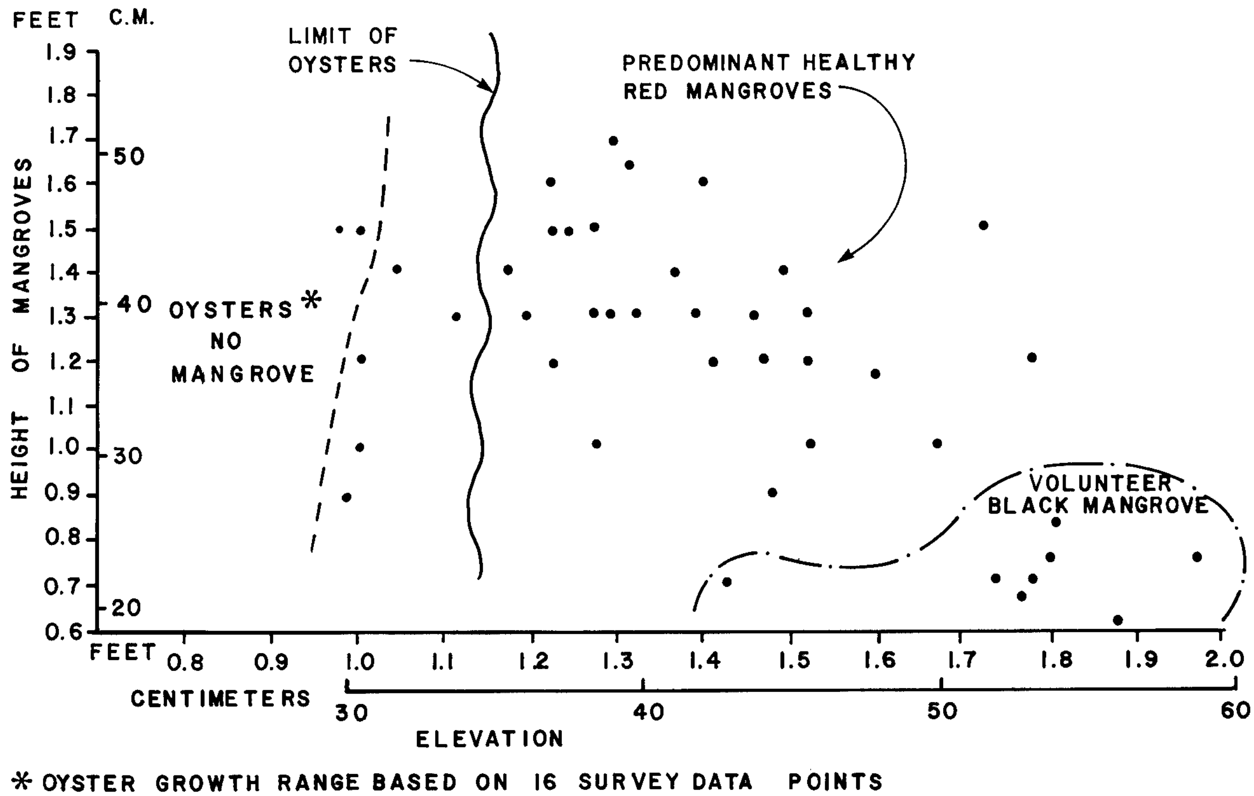


Figure 55. A comparison of mangrove height at 6 months to ground elevation (NGVD) and an interpretation of observed zonations within the Rhizophora mangle planting area at the Windstar Project (from Stephen 1983).

Biscayne Bay: As part of the Biscayne Bay Restoration and Enhancement Program, members of the Dade County Department of Resources Management (DERM) prepared a summary and survey of ten past mangrove mitigation/restoration projects in Biscayne Bay (Alleman 1982). Figure 56 shows the locations of the ten projects and Table 21 contains a summary of the information on each project.

Mangrove mitigation/restoration projects in Biscayne Bay have been mostly unsuccessful. Alleman (1982) cited a general disregard for proper planting techniques and conditions as a cause for the failure. The two most successful projects, Poinciana Island and Cocoplum, demonstrated requirements for a successful project: proper planting elevation, low shoreline energy, inaccessibility of the project to the public, and a continuous monitoring/guaranteed replacement program. Large areas of plantings at Interama Easement, Crandon Island, and South Cutler Bay were unsuccessful due to low planting elevation. Shoreline wind/wave energy caused failure of plantings at Mariner's Bay, Villa Regina, and Crandon Island and prevented recolonization at Key Biscayne Golf Course. Boat wake energy caused partial failure of the first planting at Cocoplum. Vandalism or "human interference" (Alleman 1982) destroyed the plantings at Haulover Easement and No Name Harbor.

The same general trend of loss of wetland shoreline habitat as observed in Chapter 1 of this report was documented in the Biscayne Bay report. Overall percent survival (including natural recruitment) for all of the projects was less than 40%. Alleman (1982) concluded that because of the difficulties involved in conducting successful mangrove restoration projects, more emphasis should be placed on

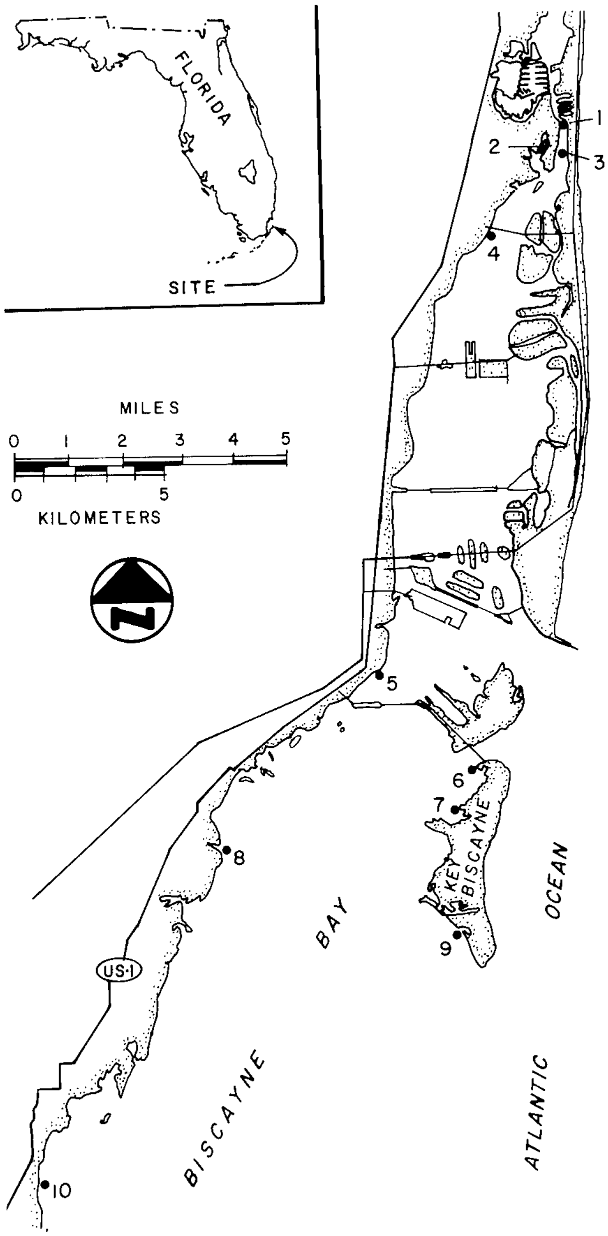


Figure 56. Location of the 10 past mitigation/restoration sites in Biscayne Bay (from Alleman 1982).

preserving existing mangrove wetlands within Biscayne Bay.

Other projects: In even the most successful planting project, maturity to a functioning mangrove wetland (which provides shoreline protection, detritus for export, and habitat for fishes and wildlife) requires many years. For projects in which enhancement of degraded habitat is required, improvement of mangrove habitats can reduce the time to gain these benefits. This type of mitigation/restoration can be illustrated by two projects: one involving the improvement of impounded wetlands on the Indian River on the east coast of Florida, and the other involving mitigation of land development at Pelican Bay, located on the Gulf of Mexico landward of Clam Pass in Collier County.

There are presently almost 16,188 ha of impounded coastal wetlands along the Indian River on the east coast of Florida (Birkett 1983). The impoundments were constructed from 1950 to 1970 by diking the perimeter of the wetlands to control water levels and to prevent oviposition by salt marsh mosquitos. Impoundment of the wetlands caused significant changes in vegetation and loss of a functional connection of the wetlands to the estuary. Preimpoundment vegetation consisted primarily of A. germinans and succulents, e.g., Batis maritima and Salicornia virginica. After impoundment and flooding, much of the area became devoid of vegetation. Some areas became secondarily vegetated with R. mangle, Ruppia maritima, Najas marina (marine naiid), and Chara sp. depending on the water depth. Typha spp. (cattails) and other freshwater species grew in impoundments where salinity levels became low. Gilmore et al. (1982) compared an impounded area to an adjacent impounded area that has been opened by breaching the dike and found that many migratory fishes were excluded from the impounded areas. Only fishes very tolerant of changing environmental conditions--e.g., Poecilia sp. (molly), Fundulus sp. (killifish), and Gambusia affinis (mosquito fish)--occur within the impounded areas. Gilmore (1985) also observed a general decrease in abundance of herbivorous fishes and an increase in abundance of detritus feeding fishes.

Efforts have begun to restore function to the impoundments by providing connections to the estuary and controlling the water level in the impoundments to allow for reestablishment of the preimpoundment wetlands vegetation. The connection of these impoundments to the

Table 21. Summary of information concerning 10 mangrove restoration projects in Biscayne Bay (adapted from Alleman 1982).

Project[a]	Years to 1982 survey	Type of action	No., type, and size planted[b]	Project size (ha)	Composition of substrate	Slope	Elevation	Exposure	Maintenance
Poinciana Island North(1)	2.7	Mitigation for destruction of shoreline mangroves during bulkhead construction	24 mature Lr 6-10 mature Ag & Rm	0.2	sand	8:1	MLW to MHW	minimal	yes
South(1)	2.3		88 Rm seedlings 100 Rm propagules		sand	8:1	MLW to MHW	minimal	yes
Interama Easement(2)	4.2	Area cleared for subterranean sewage outfall pipe	natural recruitment	0.3	muck	N/A[c]	0.15 m below MLW to MHW	none	no
Haulover Easement(3)	2.0	Area cleared for subterranean sewage outfall pipe	300 Rm seedlings	0.5	sand/muck	N/A	MLW to MHW	none	no
Mariners Bay(4)	1.2	mitigation for construction of shoreline bulkhead	300 Rm seedlings	0.02	gravel	N/A	MHW	heavy	no
Villa Regina(5)	1.1	Enforcement	300 Rm seedlings	0.01	gravel	2:1	MHW	heavy	yes
Crandon Island(6)	2.8	Experimental	1,600 Rm seedlings	1.0	sand	8:1	MLW & below	moderate	no
Key Biscayne Golf Course(7)	2.8	Mangroves killed by excessive pruning	natural recruitment	0.2	muck	8:1	-0.15 m below MLW to MHW	moderate	no
Cocoplum(8) 1st	4.5	Mitigation for canal creation in wetlands	3,000 Rm propagules	1.0	gravel	2:1	MHW	moderate to heavy	yes
2nd	2.8 - 3.3		3,000 Rm seedlings from nursery; 3,000 Rm seedlings from adjacent wetlands		gravel	8:1	MHW	light to moderate	yes
No Name Harbor(9)	1.8 - 2.4	Experimental	1,385 Rm plants air layered	0.05	gravel	2:1	MHW	moderate	no
South(10) Cutler Bay	3.3	Enforcement for illegal clearing	1,000 Rm Seedlings	0.07	muck	N/A	0.15 ft below MLW to MHW	none	no

[a] Numbers in parentheses correspond to site numbers in Figure 56.

[b] Rm = Rhizophora mangle
Ag = Avicennia germinans
Lr = Laguncularia racemosa.

[c] N/A = not applicable

adjacent estuaries is expected to benefit commercial and sport fisheries species and enhance water quality and productivity in the estuaries through habitat improvement, increased nutrient cycling, and increased detrital export (Birkett 1983).

The development of Pelican Bay, located on the Gulf of Mexico landward of Clam Pass, represents several mitigation and restoration options. The mitigation/restoration project was required as a part of the USACE permit to fill approximately 30 ha of mangrove-forested wetlands for development in the area of Upper Clam Bay (Figure 57). The wetland area on this property was studied intensively prior to issuance of the USACE permit (Heald et al. 1975; Cavinder et al. 1979). The mitigation included (G. Ward, consulting engineer; pers. comm.):

1) dedication of 231 ha of wetlands as a conservation/preservation area;
2) preservation of approximately 31 ha of hardwood hammocks;
3) creation of 5 ha of wetlands by scraping down upland areas waterward of the water management berm to intertidal elevations;
4) creation of connections from 2 ha of presently nontidal salt ponds to Upper Clam Bay;
5) creation of 2 ha of tidal ponds from upland east of Clam Bay; and
6) enhancement of approximately 8 ha of mixed mangrove/salt barren adjacent to Clam Pass by creation of tidal ponds.

Options (1) and (2) are examples of mitigation that avoids adverse impacts to wetlands and adjacent uplands. Options (4) and (6) are examples of mitigation that are acceptable when wetland habitat is not lost. The mitigation for habitat lost [options (3) and (5)] resulted in the permanent loss of 23 ha of wetlands with no assurance that the creation of the 7 ha of intertidal wetlands and salt ponds would be successful. This is an example of a project that would be unacceptable in Tampa Bay because the result would only continue the overall trend of decreasing wetland acreage in the bay.

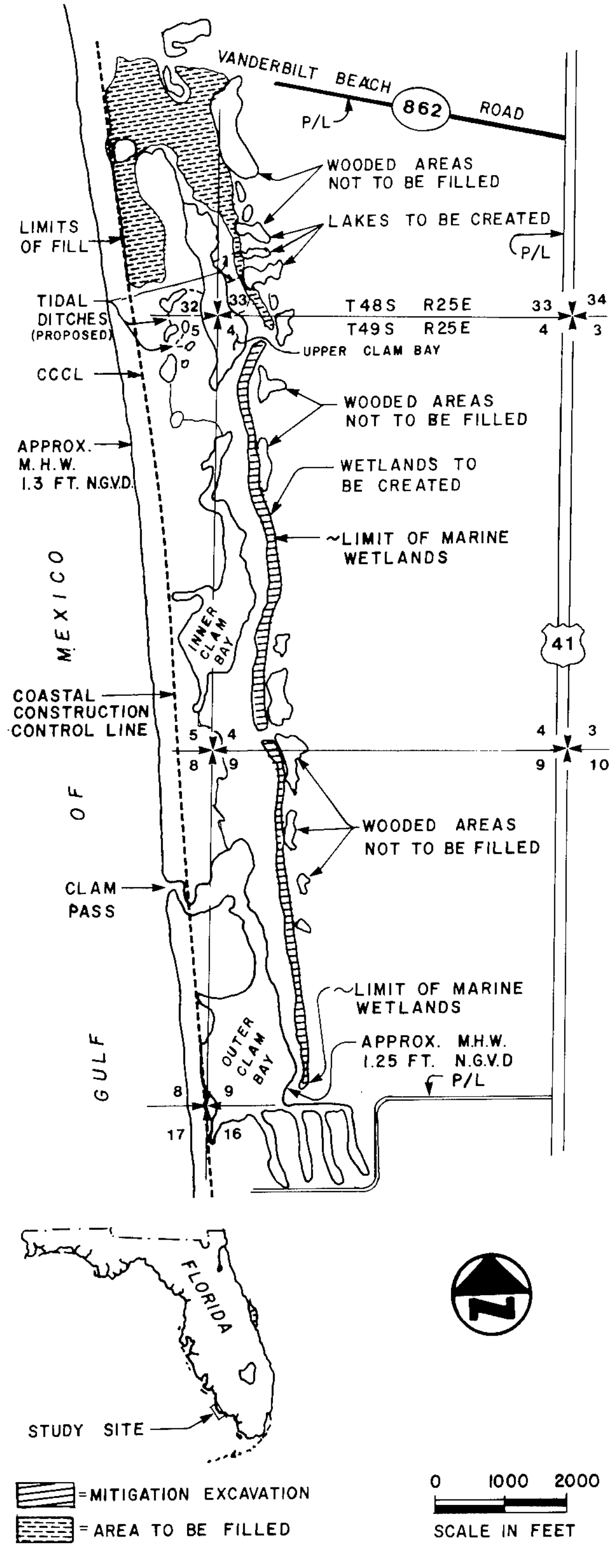


Figure 57. Location of Pelican Bay and partial representation of mitigation options provided by the project (from USACE permit no. 79K-0282).

c. Evaluation. Important factors affecting the successful establishment of mangroves have been identified as plant size and source, shoreline energy, tidal depth of planting, water salinity, and vandalism (Teas 1977). The initial cost of a mangrove planting project is determined by the plant size and source. Remaining factors affecting planting success can directly affect the cost of planting if repair or replacement is required or guaranteed. Hannan (1975) and Teas (1977) both attempted plantings along high energy shorelines. Even though the plantings on the Indian River were protected by automobile tires, boat wake and wave energy eroded those plantings whereas plantings in protected areas survived (Hannan 1975). Within 24 months, wave energy destroyed all attempted plantings along Julia Tuttle Causeway in Biscayne Bay (Teas 1977). Improper tidal elevations of the plantings or specific mangrove species within the planting have affected the success of some projects [e.g., Kinch (1975) also see Chapter 1, Section 1.3.6]. Lewis (1982b) recommends that the easiest way to ensure proper elevations at the time of planting is to survey the elevations of existing mangroves at the closest location to the proposed planting site. Mangroves are tolerant of a wide variety of substrate types; all species have been found growing in calcium carbonate rock in the Florida Keys, and in coarse to fine sand and anaerobic mud soils elsewhere in Florida. Growth rate can be slowed, however, by the poor nutrient quality of the soil. Mangroves are salt tolerant and grow best in estuarine conditions.

Hypersaline conditions can result in stunted growth or lethality, and planting in freshwater may be unsuccessful due to competition from freshwater plant species. Damage by humans will always be a problem in plantings accessible to the public.

Successful mangrove mitigation/restoration projects, in terms of percent survival of plants, occur in estuarine areas when care has been taken to attain proper planting elevations, soils are amenable to planting, and wave energy (from wind and boat wakes) and human interference (e.g., trampling, vandalism) are low. These conditions are usually found within existing large wetland areas. Projects discussed exemplifying this situation are Grassy Point and the Windstar Project; Reeder (pers. comm.) was successful with plantings in Boca Raton and Highland Beach for this reason (see Table 20).

Analysis of success in mangrove restoration projects is typically measured by percent survival of plants. Successful recovery or creation of wetland functions (e.g., usage by juvenile or migratory fishes, usage by birds, and improvement of nutrient or detrital import/export and water quality) is usually not investigated in the long or short term.

Enhancement of mangrove wetlands by improving tidal connections or by simply lowering the elevations of areas to wetland elevations (= scraping down) should be used to improve degraded wetland areas but should not be considered as mitigation for mangrove habitat lost during development. The scraping down of 5 ha to intertidal elevations with no vegetation planted at Pelican Bay did not compensate for the loss of 30 ha of mature mangrove wetlands.

2.2.3 Seagrass Habitats

Seagrasses are highly productive primary producers that serve as nursery areas and shelter for a great diversity and abundance of plant and animal species, and as sediment stabilizers (Pomeroy 1960; Odum 1963; Wood et al. 1969; Schubel 1973; Orth 1977; Phillips 1978, 1980). Human activities such as dredging and discharge of wastewater and heated effluents can destroy or damage seagrass systems, and the need to develop techniques for their re-establishment is widely recognized (Phillips 1960; Taylor and Soloman 1968; Roessler and Zieman 1969; McNulty 1970; Godcharles 1971; Strawn 1971; Blake et al. 1974; Zieman 1975). Historic losses of seagrasses in Tampa Bay and other areas of Florida have been documented (Sauers 1981; Continental Shelf Associates, Inc. 1983; Haddad 1985). The major losses have been attributed to overall loss in water clarity in the nearshore environment (Tampa Bay Regional Planning Council 1985).

a. Techniques and early experiments. Seagrass transplantation programs in Florida and the Gulf of Mexico have involved *Thalassia testudinum* (turtlegrass), *Syringodium filiforme* (manateegrass), and *Halodule wrightii* (shoalgrass). Of the three seagrasses, *H. wrightii* is a pioneering species that exhibits the broadest tolerance to environmental stresses; consequently, transplantation of this species has been the most successful. *Thalassia testudinum* is more of a climax species and has not done well in transplantation programs (Zieman 1982).

The following methods have been used in seagrass transplantation (Phillips 1982):

1) Nonanchoring methods:
   a) Vegetative shoots (= turions) (sediment washed free).
   b) Turf (= sods) (plants with sediment intact).
   c) Plugs (plants with sediment intact placed in a hole in substrate).
   d) Seeds placed in sediment.

2) Anchoring methods:
   a) Vegetative shoots (= turions) attached to various anchors (nails, iron rods, wire mesh, bricks, etc.) by various means.
   b) Seeds attached to plastic tie wraps.

Various types of growth hormones have also been used in planting experiments. Table 22 summarizes the results of experiments in Florida and the Gulf of Mexico.

Several early experimental attempts to transplant seagrasses occurred in the Tampa Bay area. Phillips (1976) began transplant experiments in Tampa Bay using sods in 1960-1961 using *T. testudinum* and *H. wrightii*. Transplantation of *H. wrightii* was moderately successful, but transplantation of *T. testudinum* was not. In 1966, Fuss and Kelly (1969) and Kelly et al. (1971) extended this work, testing root hormones and various anchoring devices. Good rhizome growth was noted on a few transplants, but the methods did not lend themselves to extensive field application. Van Breedveld (1975) transplanted plugs (plants with attached sediment) of *T. testudinum* and *S. filiforme* in Tampa and Boca Ciega Bays. The purpose of using plugs was to avoid disturbing the root system and to include some of the original soil to help prepare the receiving soil. The results varied from 0% to 100% survival depending on the location and species type.

A comprehensive experimental effort was a 2-year study done in the Florida keys for the FDOT (Continental Shelf Associates, Inc. 1982). Three species of seagrasses were planted and monitored to determine the technical feasibility of restoring large areas of submerged seagrasses in compensation for losses resulting from the replacement of 37 bridges in the Florida Keys. The site was a 1.6-ha borrow area adjacent to Craig Key. Sixteen experimental plots were established in February 1979 within the barren area of the experimental site. During the course of the 2-year project, 12 of the plots lost virtually all of the transplanted seagrasses. A synopsis of survivorship and growth of plots with survivors at the conclusion of monitoring is shown in Table 23. The most successful method used plugs of the three species at 1-m spacings. The success of the plugs was partially attributable to transfer of sediment with the root material, which reduced the shock of transplantation. Recovery of the donor site after the removal of the plugs, however, was variable. The *T. testudinum* donor site demonstrated minimal recovery in the holes left after plug removal. The *S. filiforme* donor site showed an invasion of *H. wrightii* within 3 months in the holes left after plug removal. The *H. wrightii* donor site showed no evidence of disturbance due to plant removal after 6 months. The study also produced moderate success for planting laboratory-grown *T. testudinum* seedlings.

Cost estimates for all tested methods were generated from the Continental Shelf Associates, Inc. (1982) study. Labor was estimated at the rate of $15 per hour for planting without scuba equipment. The cost of planting plugs of seagrass with

Table 22. Seagrass transplantation projects in tropical-subtropical North America (Adapted from Phillips 1982).

Species	Propagules	Anchoring method	Location	Chemical additive	Substrate: Dredged material	Substrate: Native sediment	Success (%)	Reference
Thalassia testudinum	Vegetative shoots	Iron rods	Port Aransas, TX	10% NAPH		X	0	Phillips 1980
				None			0	
"	Vegetative shoots	Nails	Port Aransas, TX	None		X	0	Phillips 1980
"	Vegetative shoots	Wire mesh	Port Aransas, TX	None	X		0	Carangelo et al. 1979
						X	Limited (6 mo)	
"	Vegetative shoots	Iron rods, concrete blocks, wire mesh	Mississippi Sound, MS	None	X		0	Eleuteris 1974
						X	4	
"	Vegetative shoots	None	Mississippi Sound, MS	None	X	X	0	Eleuteris 1974
"	Vegetative shoots	Iron rods	Tampa Bay, FL	10% NAPH		X	0 - 100 (total of 30 short shoots tested)	Kelly et al. 1971
"				None		X	0 - 16.7 (total of 30 shoots tested)	
"	Vegetative shoots	Iron rods, plastic bags	Tampa, FL[a]	5% NAPH		X	0 - 20	Van Breedveld 1975
						X	20 - 40	
"	Vegetative shoots	Concrete rings	Florida Keys, FL[a]	None		X	0	Continental Shelf Associates, Inc. 1982
"	Plugs, turfs	None	Port Aransas, TX	None		X	73 (until sediment loading and cold killed)	Carangelo et al. 1979
"	Plugs, turfs	None	Port Aransas, TX	None	X		0	Carangelo et al. 1979
						X	Limited	
"	Plugs, turfs	None	Tampa Bay, FL	None		X	0	Phillips 1974
"	Plugs, turfs	None	Tampa Bay, FL	None	X		15	Kelly et al. 1971
						X	40	

"	Plugs, turfs	None	Tampa Bay, FL	None 5% NAPH		X	0 - 100 (hormones had no effect) (highest when done in winter, i.e., water less than 21°C)	Van Greedveld 1975
"	Plugs, turfs	None	Tampa Bay, FL	None		X	0 (test for effect of thermal effluents from power plant	Blake et al. 1974
"	Plugs	None	Florida Keys, FL[a]	None	X X	X X	90 (2-m centers) 98 (1-m centers)	Continental Shelf Associates, Inc. 1982
"	Seedlings	Plastic	South Biscayne[a] Bay, FL Turkey Point, FL	10% NAPH		X	80	Thorhaug and Austin 1976
"	Seedlings	Plastic peat pots	North Biscayne Bay, FL	10% NAPH		X	5 - 33	Thorhaug and Hixon 1975
"	Seedlings	None	Florida Keys, FL[a]	None		X X X	0 (2-m centers) 6 (1-m centers) 18 (1/3-m centers)	Continental Shelf Associates, Inc. 1982
"	Seedlings	Plastic tags[a]	Florida Keys, FL	None			29 (raised in lab for 6 mo)	Continental Shelf Associates, Inc. 1982
Halodule wrightii	Vegetative shoots	Iron rods	Port Aransas, TX	10% NAPH		X	0	Phillips 1980
"	Vegetative shoots	Wire mesh	Port Aransas, TX	None	X	 X	0 Limited	Carangelo et al. 1979
"	Vegetative shoots	Iron rods, concrete blocks, wire mesh	Mississippi Sound, MS	None	X	 X	0 13	Eleuterius 1974
"	Vegetative shoots	No anchors, but placed in sediment in aquarium	Indian River, FL	0.05% NAPH 0.1% NAPH 0.5% NAPH 1.0% NAPH			28 45 73 75	Zimmerman et al. 1981
"	Vegetative shoots	Concrete rings	Florida Keys, FL[a]	None		X	0 (2-m centers) 4 (1-m centers)	Continental Shelf Associates, Inc. 1982

(Continued)

Table 22. (Concluded).

Species	Propagules	Anchoring method	Location	Chemical additive	Substrate: Dredged material	Substrate: Native sediment	Success (%)	Reference
Halodule wrightii	Plugs, turfs	None	Port Aransas, TX	None		X	58 (until sediment loading and cold set in)	Phillips 1980
"	Plugs, turfs	None	Port Aransas, TX	None	X	X	0 Limited	Carangelo et al. 1979
	Plugs, turfs	None	St. Joe Bay,[a] FL	None	X		13 overall (after 1 yr) (ultimately eroded away by surge from hurricanes)	Phillips et al., 1978
"	Plugs, turfs	None	Florida Keys, FL[a]	None		X X X	0 (2-m centers) (first planting) 0 (1-m centers) (first planting) 61 (1-m centers) (second planting using stocks from deeper water)	Continental Shelf Associates, Inc. 1982
Syringodium filiforme	Vegetative shoots	Iron rods, concrete blocks, wire mesh	Mississippi Sound, MS	None	X	X	0	Eleuterius 1974
"		Concrete rings	Florida Keys, FL	None		X X	0 (2-m centers) 0 (1-m centers)	Continental Shelf Associates, Inc. 1982
"	Plugs	None	Tampa, FL[a]	None		X	100	Van Breedveld 1975
"	Plugs	None	Florida Keys, FL[a]	None		X X	0 (2 m centers) 61 (1-m centers; those remaining expanded over 75 of a 49 m^2 plots)	Continental Shelf Associates, Inc. 1982
Ruppia maritima	Vegetative shoots	Wire mesh	Port Aransas, TX	None		X	0	Carangelo et al. 1979
"	Plugs	None	Port Aransas, TX	None		X	0	Carangelo et al. 1979

[a]Discussed in text.

Table 23. Synopsis of survivorship and growth of test plots with survivors from FDOT seagrass transplantation study at Craig Key in the Florida Keys (from Continental Shelf Associates, Inc. 1982).

Treatment	Survivorship[a] (%)	Growth[b] (%)
Thalassia plugs with 1-m spacings	98	60
Thalassia plugs with 2-m spacings	90	40
Laboratory raised *Thalassia* seedlings anchored with 1/3-m spacings	29	-
Laboratory raised *Thalassia* seedlings unanchored with 1/3-m spacings	18	-
Halodule plugs with 1-m spacings	61[c]	120
Halodule turions with 1-m spacings	4[c]	-
Syringodium plugs with 1-m spacings	61	1,700

[a]All survivorship measured after 2 years unless indicated.
[b]Measured as % growth from planting unit.
[c]Second planting 14 February 1980 (1 year of monitoring); first *Halodule* planting had 0 survivorship.

1-m spacings ranged from $27,061 to 67,652/ha.

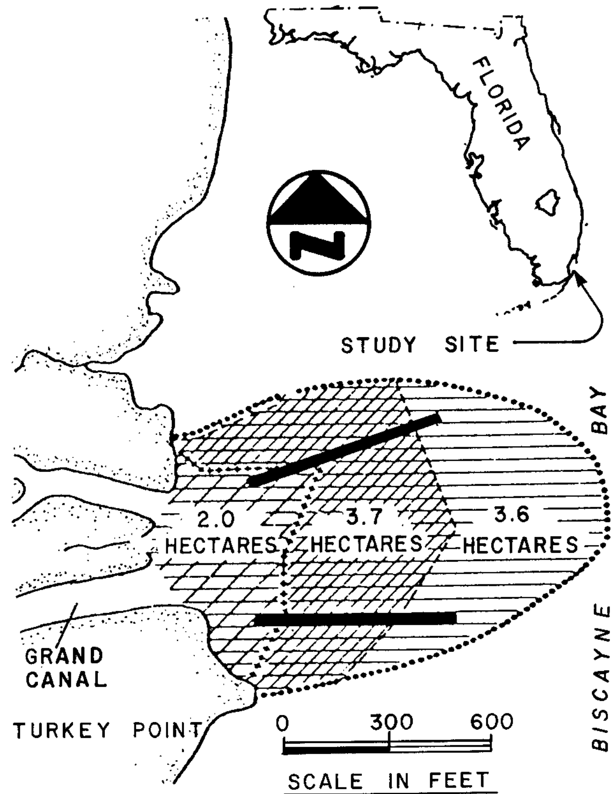
Lake Surprise: Derrenbacker and Lewis (1982) experimented with three methods of seagrass planting in an area of Lake Surprise, Key Largo, Florida, where water pipeline installation had destroyed or damaged an existing seagrass bed. In the first planting method, 15-cm steel staples were used to anchor 10- to 30-cm long runner sections of *H. wrightii* on 0.6-m centers. This method allowed long shoots of *H. wrightii* to be taken without actual removal of the main plant or disturbance of the sediment. (Under low current conditions, *H. wrightii* sends "runners" reaching up to 1 m in length into the water column.) In the second method, *T. testudinum* seedlings were hand broadcast on approximately 0.3-m centers. In the third method, sections of *T. testudinum* rhizomes with attached short shoots were transplanted on approximately 0.3-m centers. After 7 months, *H. wrightii* had an average 72% coverage of the planted area (100% coverage in a moderately impacted area nearby). *Thalassia testudinum* seedlings had an average 50% survival rate in the planted area, and *T. testudinum* rhizomes with short shoots had a 75% survival rate in the planted areas.

b. Selected projects. Turkey Point, Biscayne Bay. Turkey Point, approximately 32 km south of Miami on the western shoreline of Biscayne Bay, was the site of an early attempt (Thorhaug 1974) to plant T. testudinum seedlings. The restored site was a former canal mouth where heated effluents from two fossil fuel plants had totally denuded an area of approximately 9 ha of T. testudinum and other macrophytes (Figure 58). Discharges of heated effluent stopped in 1972 when the power plant was converted to a freshwater, radiator cooling canal system.

The seedlings were raised from fruit collected by hand from densely-fruiting beds in the Caribbean Sea. The seeds were transported to Miami under running water conditions. Various growth-promoting chemicals were tested; exposure to 10% napthalene acetic acid (NAA) for 1 h resulted in increased root propagation by the seedlings.

The planting technique involved the use of 12-cm long plastic anchors with red nylon lines attached to make locating the seedlings easier. Seedlings were planted in two parallel corridors, 150 m long and 6 m wide, within the denuded area (Figure 58). The area consisted of three zones: approximately 2 ha of bare peat near the mouth of the canal; approximately 37 ha of green macroalgae consisting chiefly of Acetabularia crenulata, Batophora oerstedii, Caulerpa sertularioides, Halimeda incrassata, and Penicillus capitatus; and approximately 3.5 ha of secondary growth of H. wrightii on the bayward edge of the denuded zone. Planting intervals of 1.0, 0.5, 0.25, and 0.1 m were utilized in an alternating pattern repeated each 50 m (corresponding roughly to the three major zones). Approximately 15,000 seedlings were planted in August 1973.

Thorhaug (1974) reported the results of the effort 9 months after the restoration. The percentage of plants missing, dead, or dormant was reported as 31.2%. Ten percent of the seedlings were reported as "escapees," i.e., missing but growing in adjacent areas. All living seeds had fairly extensive leaf growth.



NOTE: SIX ROWS OF THALASSIA SEEDLINGS WERE PLANTED IN EACH OF THE TRANSECTS. INNERMOST 2.0 ha-BARE PEAT BOTTOM, 3.7 ha-GREEN MACROALGAE, AND OUTERMOST 3.6 ha-HALODULE WRIGHTII ZONE. TOTAL AREA IS APPROXIMATELY 9 ha.

Figure 58. Mouth of Grand Canal showing originally damaged areas and two 150-m transect lines (from Thorhaug 1974).

Thorhaug (1979) continued monitoring for 4 years after planting. In April 1977, blade density was 2,030/m^2 in the restored areas, 0 to 10/m^2 in the unrestored areas into which T. testudinum was expanding, and 2,295 blades/m^2 in control areas. Abundant flower production (up to 34/m^2) was also observed. By fall of 1977, the original seedlings had expanded by rhizome growth and seed production throughout 7.5 ha of the 9-ha denuded area.

A 1976 review of the project (Thorhaug and Austin 1976) included a cost analysis of the planting of T. testudinum seedlings raised from seed. Table 24

Table 24. Direct monetary costs of collection, nursing, and planting seagrasses based on the Turkey Point restoration project in Biscayne Bay (Adapted from Thorhaug and Austin 1976).

Years to achieve desired cover	Desired cover (blades/m^2)	Planted area (m^2)	No. of seeds planted	Cost of collecting seeds	Cost of nursing for early autumn planting	Cost of planting	Partial direct cost[a]
2.5	3,000	10,000	43,602	$ 4,796	$ 2,916	$13,516	20,928
2.5	4,000	10,000	58,136	6,394	3,488	18,022	27,904
0.8	1,000	10,000	145,340	15,987	8,720	49,055	69,762
0.8	2,000	10,000	290,680	31,974	17,440	90,110	139,524

[a]Excluding costs of transportation between collection and planting sites, depreciation on capital equipment, administrative overhead, etc. Values are in 1976 dollars.

gives a partial listing of the parameters included in the analysis and the estimated cost of the planting (in 1976 dollars).

Port of Miami, Biscayne Bay: The seagrass revegetation project undertaken by the Port of Miami was a special requirement of the USACE dredge-and-fill permit issued in October 1980 for expansion of port facilities in Biscayne Bay. The USACE required the Port to plant 100 ha of unvegetated or sparsely vegetated bottom in Biscayne Bay with the seagrasses *T. testudinum*, *S. filiforme*, and/or *H. wrightii* to mitigate the anticipated loss of seagrass beds during the expansion project.

An April 1980 mitigation plan by the Port consultant (Post, Buckley, Schuh, and Jernigan, Inc.) outlined the objectives of the seagrass restoration program, reviewed the results of past studies in Biscayne Bay, and recommended general planting and monitoring procedures. The detailed specifications for planting and monitoring were prepared in October 1981. The program was divided into two phases. Phase I included the planting and monitoring of one 10-ha and thirteen 0.4-ha test plantings intended to provide guidance for the planting of the remaining 85 ha in Phase II.

The experimental design and site selection for Phase I was done by Applied Marine Ecological Services, Inc. (AMES). Phase I consisted of two components. One was a 10-ha planting effort involving three small study sites near Mercy Hospital (Figure 59); the objective of this planting was to determine the costs involved in planting large areas with seagrasses. The second component was an experimental design to determine which areas within Biscayne Bay were most amenable to seagrass restoration and which combinations of species and planting methods could be expected to succeed in each area. Thirteen 0.4-ha test plots were planted in different areas of Biscayne Bay (Figure 59). Each was representative of a larger area of potentially plantable bay bottom, and each was subdivided to test two planting methods for each of the seagrass species and provide an unplanted control. The planting methods involved seeds and shoots for *T. testudinum* and plugs and shoots for *S. filiforme* and *H. wrightii*.

The experimental design was to evaluate the effects of location, species, and planting method. Several inconsistencies in methodology confounded the experimental design, however. Planting occurred through several seasons, from March to November 1982. Different anchoring devices for shoots and seeds were used during the course of the planting; hair pins (clips) were substituted after steel reinforcing bar

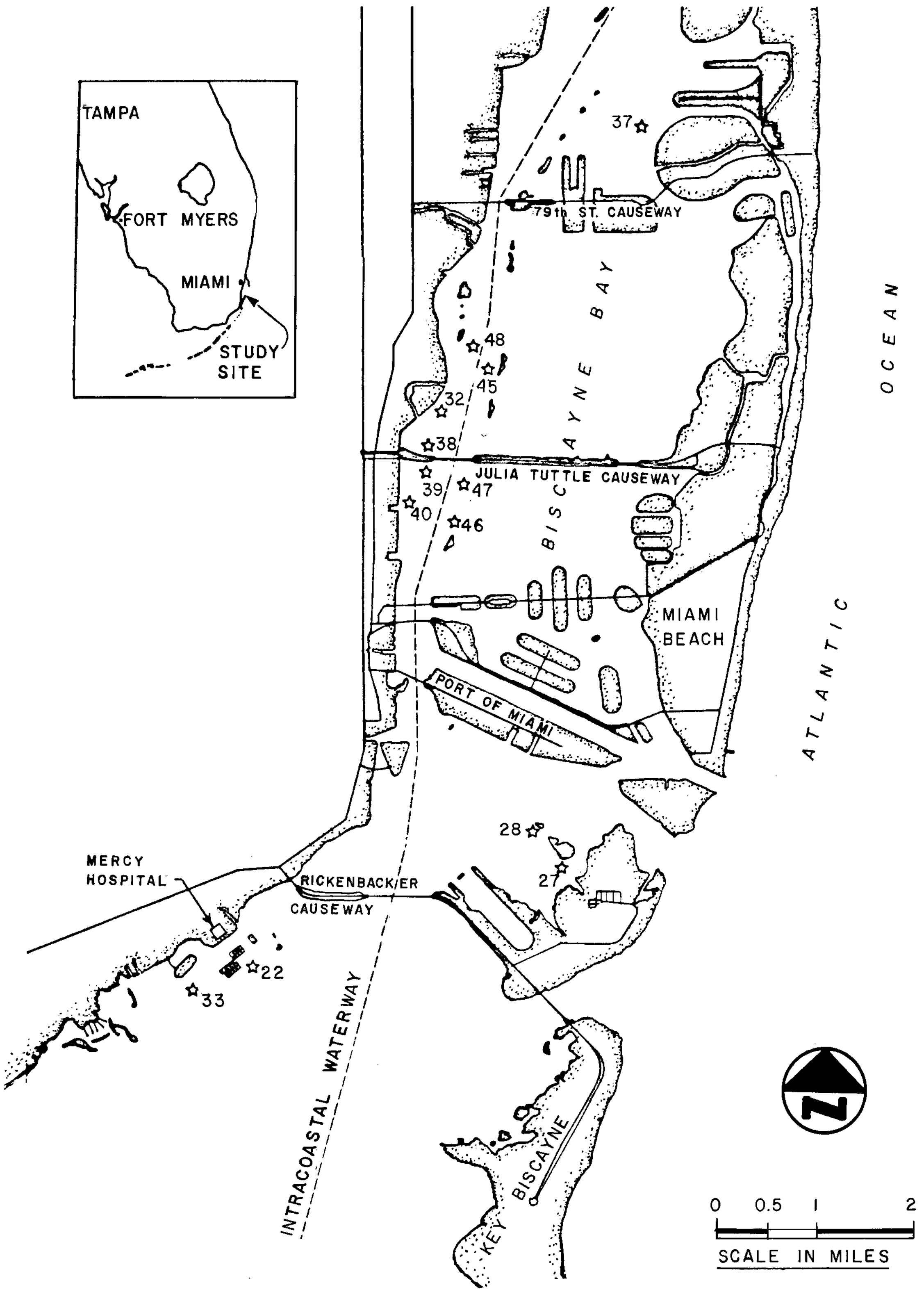


Figure 59. Map of Biscayne Bay showing test plot locations (stars) and numbers and the location of the 10-ha planting near Mercy Hosptial (from Connell Associates 1984).

(re-bar) was found to cause deterioration of the planting units. Plugging was found to be very labor intensive and was discontinued early in the program; only seven plots were plugged (six of *H. wrightii* and one of *S. filiforme*). *Thalassia testudinum* seeds were also not planted as extensively as proposed. The final planting design is illustrated in Figure 60. All planting was done on 1-m centers.

Connell Associates was contracted to monitor the planting effort of AMES. Compliance monitoring (Connell Associates 1984) was done soon after each planting to evaluate the planting effort, provide baseline data for later survival estimates, and record the extent and density of natural grass beds within the site. Qualitative monitoring consisted of monthly observations in which each plot was rated good, fair, or poor. Quantitative survival monitoring was conducted on each plot approximately 12 months after planting. Linear spread, presence and health of rhizomes, and blade length and density (for *T. testudinum*) were also evaluated, as the objective of the seagrass restoration program was to plant small units of grass that would expand and coalesce to form functional seagrass communities.

Survival rates ranged from 0% to 100% within the plots; the overall survival rate for Phase I was 12%. The mean survival rates by species and method for the experimental plots are listed in Table 25. The survival rate for sample plots in the 10-ha plot was very low (maximum percent survival for *H. wrightii* shoots at the 10-ha site was 34%; for *T. testudinum* seeds, 3%). The goal of the seagrass restoration program was to achieve an overall survival of 70%, but only 22% of the tested plots achieved 70% survival.

The highest survival rates were achieved using *T. testudinum* and *H. wrightii* shoots planted with clips. *Thalassia testudinum* shoots survived well but grew slowly. *Halodule wrightii* shoots exhibited inconsistent survival rates; two plots, however, coalesced into a continuous bed within the first year. Moderate to high survival rates were achieved using plugs of *H. wrightii* and *S. filiforme* (only one test plot planted). This method, however, proved to be very labor intensive. The lowest survival rates were achieved using *S. filiforme* shoots and *T. testudinum* seeds. Both failed because of insufficient anchoring and/or a physiological problem.

Planting success varied depending on geographic location within Biscayne Bay. The most successful sites were in clear water and not exposed to wave action.

After the completion of Phase I, Phase II began in the summer of 1984 with the planting of 6 ha of *H. wrightii* shoots and 2 ha of *T. testudinum* shoots anchored by clips. The seagrasses were planted on 0.9-m centers south of Julia Tuttle Causeway in north Biscayne Bay. First year monitoring began in the summer of 1985.

New Pass Channel, Sarasota County: The revegetation of seagrasses in New Pass Channel was done to mitigate the filling of 0.06 ha of seagrasses during the construction of a new bridge for State Road 789. The fill area contained a 0.06-ha bed of approximately a 50/50 mixture of *H. wrightii* and *T. testudinum*. This area was used as the donor site (Figures 61 and 62). The primary transplant site was a 0.2-ha site between two remnant grass beds on the flood tidal delta of New Pass Channel.

Using plugs removed from the construction site, plantings on 0.6 m centers were used to plant 0.2 ha. The 5,445 plugs were half *T. testudunium* and half *H. wrightii*. Replacement plants were, or will be, commercially produced plants grown from viable plants floating at the sea surface or in the wrack line or collected seeds or seedlings.

The plantings were monitored by randomly placing ten 0.9-m^2 quadrats in the planted area and counting the number and type (species) of surviving planting units and the percent spread (defined by expansion out of a 15-cm diameter circle placed over each surviving unit). Survivorship was guaranteed by the contractor (Lewis 1983); at one year past planting, if not 75% successful, dead or

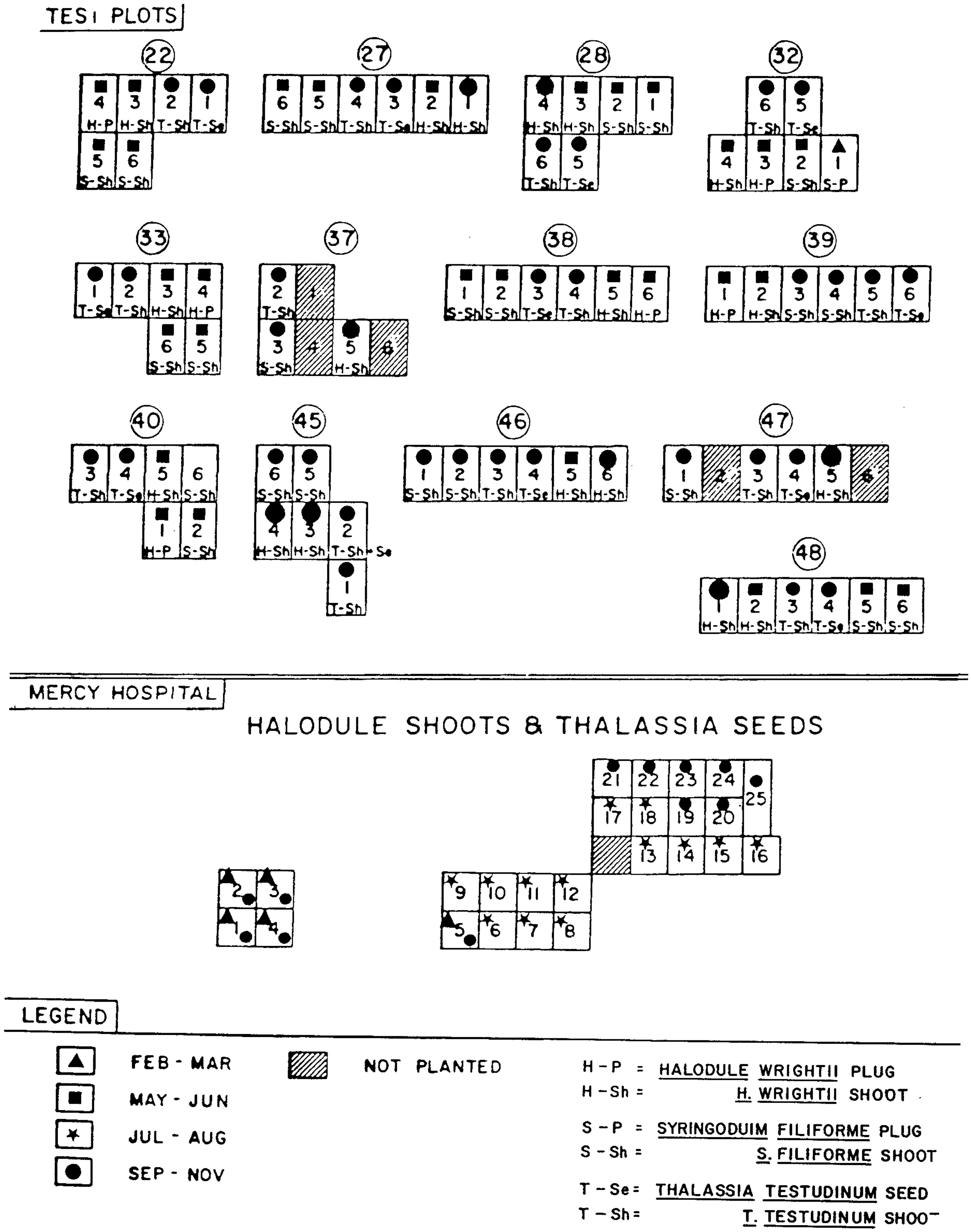


Figure 60. Planting period for all Halodule subplots and the Halodule and Thalassia plantings in the 25 0.4-ha plots near Mercy Hospital (adapted from Connell Associates 1984).

Table 25. Mean survival rate by species and method for seagrasses transplanted into test plots in Biscayne Bay (Adapted from Connell Associates 1984).

Species	Method	No. plots	Percent survival Mean	Range
Halodule wrightii	Plugs	6	29.5	0 - 88
	Shoots	18	48.0	0 - 117
Thalassia testudinum	Seeds	11	6.3	0 - 25
	Shoots	14	73.1	0 - 112
Syringodium filiforme	Shoots	23	9.3	0 - 56

missing plants were to be replaced to achieve the original number of plants. For the second year, 60% survivorship was guaranteed and the dead or missing plants were to be replaced to achieve the original number of plants. If survivorship is below 60%, the same number of plants are to be planted at a contingency site. No monitoring will be conducted.

In the 9-month monitoring report (12 June 1984), survival rate for shoot transplants was reported as 39% and a decrease in the mean number of plants per planting unit was observed. The decrease in viability of the coverings was attributed to predation and shifting sediments. The guaranteed replacement and 12-month monitoring report are to be completed by the contractor in the spring of 1985 (R. Lewis, Mangrove Systems, Inc.; pers. comm.).

c. _Evaluation_. The case studies reviewed _illustrate_ the difficulty of seagrass revegetation. The recommendation is that seagrass habitat not be destroyed with expectation of mitigation by planting seagrasses. At the present time the revegetation of seagrasses is experimental. The planting methods are not proven and the problems affecting planting success are not known. Successful re-establishment has occurred in some damaged seagrass habitats, but planting on dredged material (see Section 2.3) or in previously unvegetated areas has not been very successful.

When successful, re-establishment of seagrasses has been shown to result in increased animal species and abundance. McLaughlin et al. (1983) found that successful re-establishment of _T. testudinum_ at Turkey Point in Biscayne _Bay resulted_ in significantly more abundance and species of organisms in restored areas than unvegetated barren areas and that restored sites were not statistically different from control _T. testudinum_ sites.

The most successful revegetation attempts have utilized the pioneering aspects of _H. wrightii_ (see Lake Surprise and Port of _Miami_). _Halodule wrightii_ planted as shoots has _been proven to have_ inconsistent, but at times, good survivorship with comparatively rapid spread from the planting unit, providing stabilization of sediment. The cost of planting shoots is less than with the labor intensive plug method. The use of shoots of _H. wrightii_ does not cause major disruption _of the donor_ grass beds, especially if the "runners" described by Derrenbacker and Lewis (1982) are used.

The use of _T. testudinum_ shoots or seeds has been _successful, but_ spread from the planting units is slow (see Lake

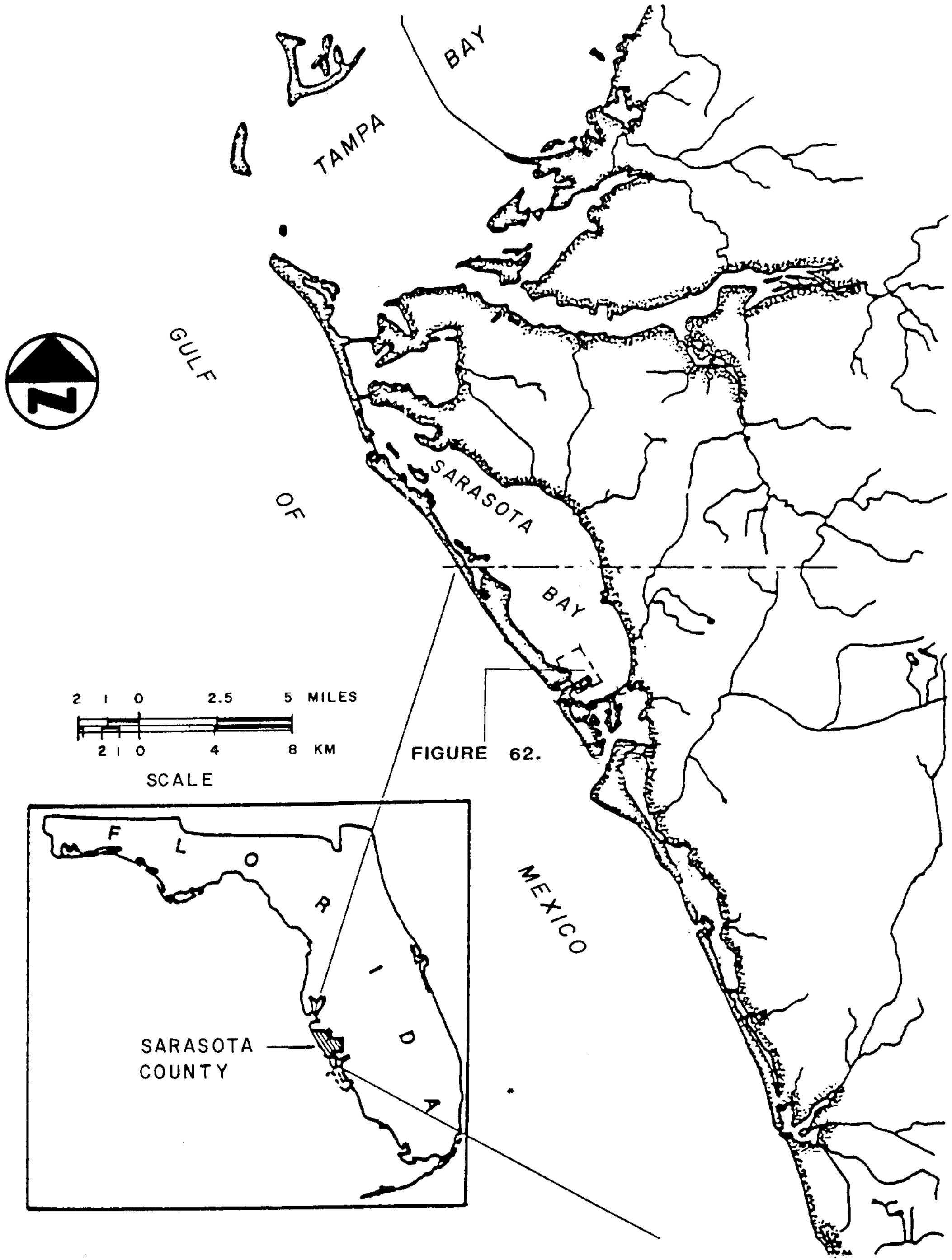


Figure 61. Location of New Pass Channel (from Sauers 1981).

Surprise, Turkey Point, and Port of Miami). Shoots, seedlings, or seeds of _T. testudinum_ planted within sparse or recently revegetated beds of _H. wrightii_ may aid in the acceleration of the vegetative community to climax state. This method was used with good success at Turkey Point with _T. testudinum_ seeds. The success of the restoration at Turkey Point can also be attributed to the

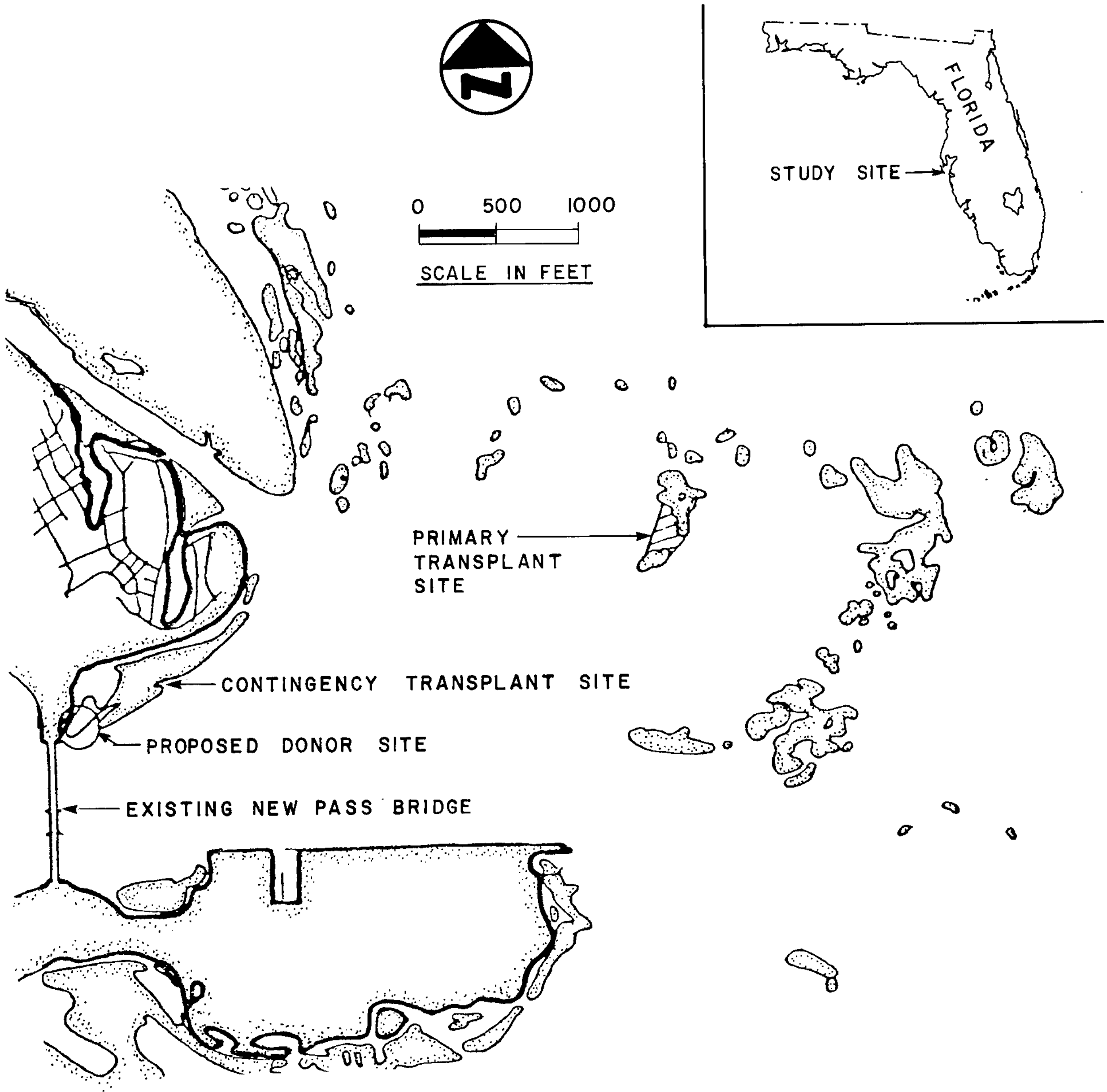


Figure 62. Project area showing existing seagrass meadows, proposed donor site, primary transplant site, and contingency transplant site (from Lewis 1983).

quality of the sediment, which had not changed after being denuded by heated effluent and low wave energy.

Syringodium filiforme has not been used extensively in planting projects. The results, therefore, are insufficient to make conclusions on use or planting means.

Test plantings should be done before undertaking any large-scale seagrass restoration projects in Tampa Bay. The basic concept and design of the multiple-phase Port of Miami Seagrass Restoration Project is the best approach. If the inconsistencies that existed in Phase I of that project were avoided in future projects, this approach would allow

one to identify the species, planting methods, and locations best suited for a large-scale planting project.

The loss of seagrass cover in Tampa Bay has been attributed to a reduction of light penetration to the bottom caused by an increase in substances in the water column in recent years. These substances can include suspended sediment, detritus, tannins, and phytoplankton and have been caused by dredge-and-fill activities and point and nonpoint discharges of surface water and sewage (TBRPC 1985).

The Future of Tampa Bay (TBRPC 1985) discusses the current trends of certain water quality parameters in the bay and proposes prioritized solutions in an issue analysis section. Specific water quality parameter trends identified in The Future of Tampa Bay were:

1) a significant decline, over the past decade, in bottom dissolved oxygen levels and a slight increase in surface levels;
2) a baywide trend toward improvement of effective light penetration following minimum values recorded in 1979;
3) a baywide trend toward declining phosphorus levels since 1973; however, the highest phosphorus concentrations found in any major estuary or coastal area studied exist in Tampa Bay;
4) due to the large reservoir of nitrogen in the sediments, the sediments of Tampa Bay will continue to exacerbate water quality problems for many years.

Specific issues identified which will further reduce the quantity of substances in the water and increase the effective light penetration include:

1) controlling nonpoint discharges into the bay;
2) gypsum field decommissioning; and
3) storm water detention requirements for redevelopment.

The water quality problems of Tampa Bay will be improved with the initiation of the changes identified above; however, the quantity of improvement required to encourage seagrass growth through increased light penetration will not occur for many years.

2.2.4 Other Intertidal and Subtidal Habitats

a. Artificial reefs. Artificial reefs are structures of scrap material (e.g., ships' hulls, construction debris, automobile bodies, tires) placed on the bottom to enhance fish habitat in coastal and estuarine waters. When properly constructed, these reefs can provide hard-bottom habitat for attached organisms and increase total fish biomass without detracting from the biomass potential of the area (Stone et al. 1979).

As a part of the Biscayne Bay Restoration and Enhancement Program, DERM has constructed several artificial reefs in the coastal waters off Dade County and within Biscayne Bay (B. Mostkoff, DERM; pers. comm.). Offshore reefs have been constructed of a variety of materials and placed at various depths (for details concerning locations, composition, and depth, see Aska and Pybas 1983). At least three artificial reefs have been constructed within Biscayne Bay. The Julia Tuttle site was an attempt to construct artificial reef habitat in a submerged borrow pit, originally constructed for causeway fill. Automobiles, small boat hulls, concrete rubble, and fuel tanks were placed in the pit. Some material initially settled into the soft bottom of the pit, but once a base had been built, the remaining materials protruded from the bottom, providing the intended relief. Although no monitoring data have been collected, the area has been reported to be a fish haven (B. Mostkoff, DERM; pers. comm.).

There are 173 permitted artificial reefs in Florida (Aska and Pybas 1983). Most have been constructed in offshore coastal waters, but a few have been constructed within estuarine embayments. Three artificial reefs have been constructed within the Tampa Bay watershed (Aska and Pybas 1983)--two along the Manatee River, and one within Tampa Bay off St. Petersburg. There are no data concerning the effectiveness of these structures as artificial reefs.

Artificial reefs should be constructed to enhance the production of selected fisheries that have experienced or are expected to experience declines. For many years the Japanese have been designing and constructing reefs to enhance specific mollusc, crustacean, or finfish fisheries (Stone 1982). In 1965, the City of Clearwater (Pinellas County) built and emplaced 200 Japanese-style "pill box" reef units to enhance lobster habitat. Each box measured 2.4 m x 1.2 m x 0.9 m and had 46-cm diameter holes in the sides and top. Due to inadequate planning and improper placement, however, approximately only 20 units can be found in the intended area of placement; the rest are scattered over an unknown area of bottom (Sheehy 1982). Panama City and Jacksonville were selected as sites to test Japanese fiberglass reinforced plastic reefs in Florida (Sheehy 1982). The reefs have been installed and are currently being monitored.

Artificial reefs should be carefully constructed, designed, and placed or the purpose of fishery enhancement will not be achieved.

b. Oyster reefs. The ecological, economic, and historical importance of oyster reefs in Florida has been reviewed by Darovec et al. (1975). The chronic effects of development are the primary reasons for the decline in the number and size of oyster reefs. These effects can be divided into three categories (Schomer et al. in prep):

1) turbidity from dredging, runoff, and effluent discharges;
2) hydrologic flow through modifications resulting from dredging, canal and seawall construction and upland development; and
3) discharges of bacteria, nutrients and potential toxins from industry, municipal, and non-point source runoff.

Large, growing aggregations of oysters still can be found in areas of Tampa Bay (Kunneke and Palik 1984). Only a few are found within the FDNR approved shellfish harvesting areas located at the mouth of Tampa Bay. Although they were historically an important fishery resource, oysters are presently not a commercially important shellfish within the bay; in 1982, only 132 pounds worth $167 were brought in [Snell (1984) cited in Kunneke and Palik (1984)].

The growth of oyster reefs can be initiated by the means discussed in Darovec et al. (1975): planting of cultch (any material placed in the water to collect spat, e.g., old oyster shells), planting of seed oysters, relaying, and string culture. The placement of cultch is inexpensive--$875 to $4,000/ha--according to Darovec et al. (1975). There have been no documented oyster reef formation projects in Tampa Bay. The water quality problems that have caused the decline of the oyster population in the bay, however, need to be improved before large-scale oyster reef development can be successful in Tampa Bay.

c. Mud flats. The importance of intertidal mud flats is often ignored because the lack of macrophytic vegetation gives them a barren and unproductive appearance. The term "mud flat" is used here to refer to any unvegetated shoreline that is exposed by the tides, including intertidal flats composed of sandy sediments as well as those dominated by true muds (Peterson 1981). Although no projects can be cited that were initiated specifically to construct mud flats, the consequences of a restoration attempt that resulted in a mud flat are exemplified by the Feather Cove Project (Chapter 1, Section 1.3.8). The shallow mud flat at this site apparently provided suitable habitat for prey species important to shallow-feeding shorebirds. Use of mud flats by this group has been noted by Peterson (1981). Sunken Island (Chapter 1, Section 1.3.5) also supported a diverse assemblage of shorebirds and wading birds (see Nesbitt et al. 1982) using the various habitats present including mud flats. The fishes and crustaceans consumed by wading birds feed upon benthic invertebrates that abound in and on the sediments of the mud flats. Shorebirds are also important predators of these invertebrates (Peterson 1981). Many benthic invertebrates, in turn, consume microalgae, which are the primary

producers in this habitat. Although not as conspicuous as the familiar shoreline marsh grass and mangrove vegetation, microalgae are an important food source because they are rich in labile energy and protein; they are used directly by the animals (rather than indirectly via microbially mediated breakdowns for marsh grass, seagrass, or mangrove detritus) (Figure 63); and they are regenerated rapidly when grazed (Peterson 1981).

The preceding discussion is not intended as an argument for creation of mud flats as mitigation for unavoidable environmental impacts, as these habitats are not in short supply. Mud flats are, however, an important component of coastal ecosystems and should not be ignored in the design of large mitigation projects.

2.3 USE OF DREDGED MATERIAL IN MITIGATION/RESTORATION

Spoil material from dredging projects in Tampa Bay has been and will be used to create habitats which can serve to enhance fish and wildlife resources and estuarine productivity. Various uses of dredged material that have been discussed as most feasible in Tampa Bay (Auble et al. 1984; W. Fehring, Tampa Port Authority, pers.

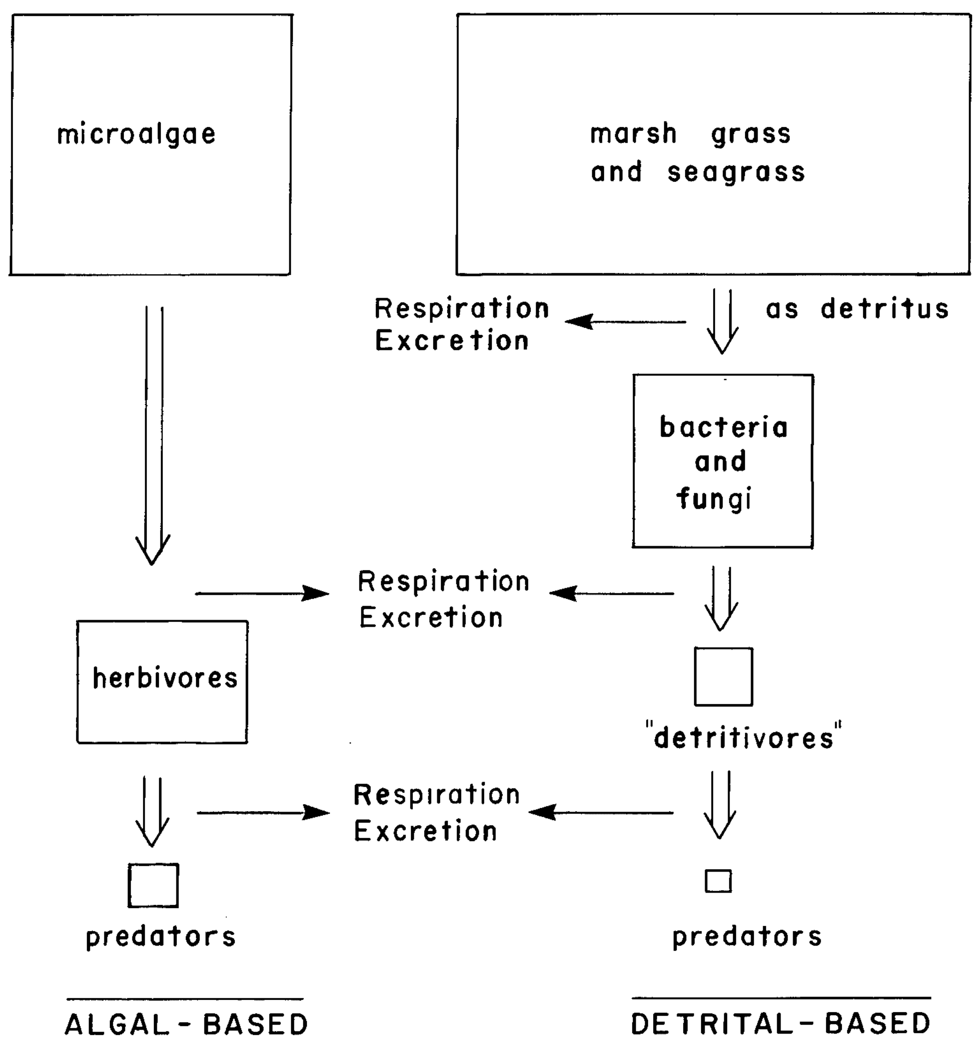


Figure 63. Energy flow through estuarine food chains (adapted from Peterson 1981).

comm.) include: creation of islands for restoration of marsh and mangrove habitat; filling of submerged borrow pits, channels, or canals for restoration of sand bottom or seagrass habitat; restoration of shoreline marsh and/or mangrove habitat; and restoration of shoreline for intertidal and subtidal sand- and mud-bottom habitat. The use of dredged material to create habitats involves destruction and creation of new habitats at both the project construction site (e.g., channel building) and spoil placement area. Evaluation of the suitability of dredged material for mitigation or compensation must include knowledge of the historic trends in habitat area in Tampa Bay. Habitat losses obtained through the use of dredged material may be greater than the gains. Only habitat creation on spoil islands has been evaluated in South Florida. The following is a review and evaluation of relevant past projects where dredged material was used to create new habitats.

2.3.1 Dredged Material Research Program

The USACE is charged with the responsibility of planning, constructing, and maintaining harbors and waterways, consequently producing large quantities of dredged material. Public concern for the quality of the environment has caused once routine dredging and disposal practices to be questioned. To address this concern, the Office of Dredged Material Research (ODMR) was created at the USACE Waterways Experiment Station (WES), and the Dredged Material Research Program (DMRP) was designed and implemented between 1973 and 1975. The overall objectives of the DMRP were:

1) to provide definitive information on the environmental impact of dredging and dredged material disposal operations; and
2) to develop technically satisfactory, environmentally compatible, and economically feasible dredging and disposal alternatives, including consideration of dredged material as a manageable resource.

One of the primary efforts of the DMRP was to assess the feasibility of developing habitat on dredged material substrate. To accomplish this, the Habitat Development Project (HDP) conducted several field studies in marsh, island, upland, and aquatic habitats. In studies of marsh habitat development, the HDP specifically sought to demonstrate and evaluate the environmental, economic, and engineering feasibility of using dredged material as a substrate for marsh habitat development (Kruczynski et al. 1978; Lunz et al. 1978; Smith 1978).

The HDP resulted in two studies on the Gulf of Mexico coast of Florida. The Apalachicola Bay field project (Kruczynski and Huffman 1978; Kruczynski et al. 1978; Newling et al. 1983) was designed to test the feasibility of propagating selected marsh plants on fine-grained and coarse-grained dredged materials that had been placed in a saline intertidal environment. The optimum spacing interval for planting selected species was also investigated. The study site was Drake Wilson Island (Figure 64), the disposal site for the dredging of Two Mile Channel. An intertidal area was formed within the island by construction of a containment dike with a weir for tidal influx around the island. Two species of marsh plants, *S. alterniflora* and *S. patens*, were transplanted from natural stands and established on the dredged material substrate at various interval spacings (Figure 65). After 14 months, the plots of *S. alterniflora* and *S. patens* exhibited substantial growth (Kruczynski et al. 1978). *Spartina alterniflora* transplants did well when planted at 0.3- to 0.9-m intervals but did poorly when planted at wider intervals. *Spartina patens* exhibited excellent growth at all spacing intervals and was recommended to be planted at 1.8- to 2.7-m spacing intervals. Drake Wilson Island was visited annually from 1980 to 1982 (Newling et al. 1983) to further investigate plant and animal succession, stability, and the ecological condition of the site. In the period following the HDP experiment, the dike was breached and eroded by storm tides and wave action. *Spartina alterniflora* densely covered the interior of the disposal area except for one small ponded area of subtidal elevation in the center of the site. The ponded area was used heavily for feeding

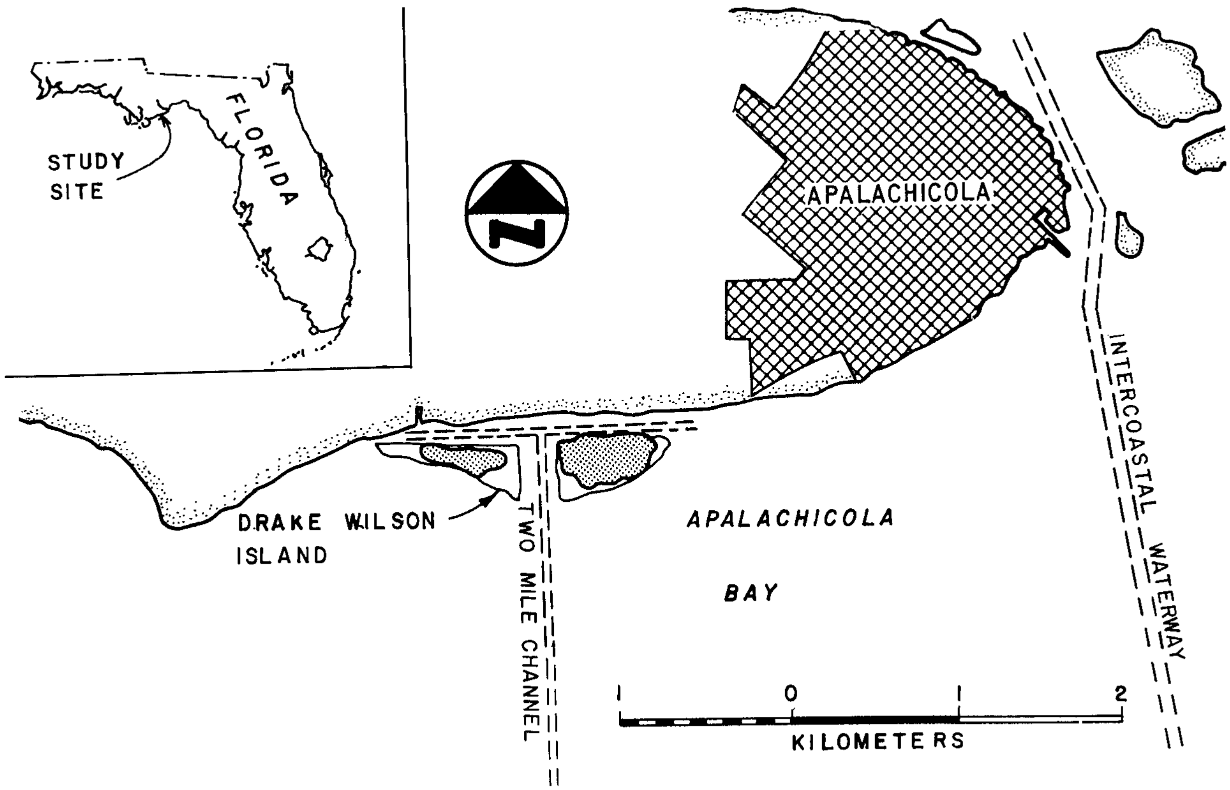


Figure 64. Location of Two Mile Channel, Drake Wilson Island, and another disposal island formed in the construction of Two Mile Channel (From Kruczynski et al. 1978).

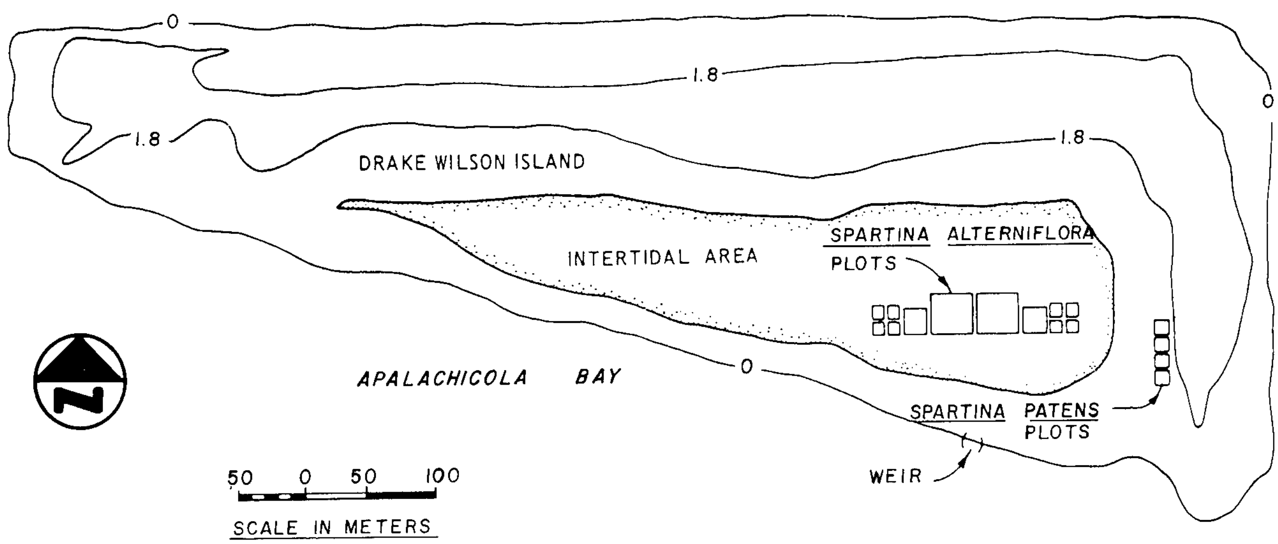


Figure 65. Study site on Drake Wilson Island, June 1976 (from Kruczynski et al. 1978).

by wading birds, primarily herons and egrets. The intertidal area supported a large population of clapper rails. Much of the original S. patens had been smothered by the shifting loose sand on the uplands.

The second HDP study was the Port St. Joe field project (Phillips 1977; Phillips et al. 1978), designed to test the feasibility of transplanting the seagrass Halodule wrightii (shoalgrass) on subaquatic, unconfined, coarse-grained dredged material (Figure 66). Halodule wrightii was chosen for its suitability to local substrate conditions and tolerance to environmental extremes. Two sizes of plugs, 177 and 275 cm^2, were removed from a natural bed and planted on 0.9-, 1.8-, and 2.7-m centers in two replicate plots. Survival, growth, and production of the plantings were monitored for 13 months. During the 13 months, the site experienced extremes in exposure, was subjected to erosion and siltation, and was continuously bathed by tannic water from freshwater wetlands and kraft-mill effluent from a paper mill. This combination of factors weakened the plantings and the survival rate declined until heavy surf from two hurricanes in 1977 caused complete failure of the project.

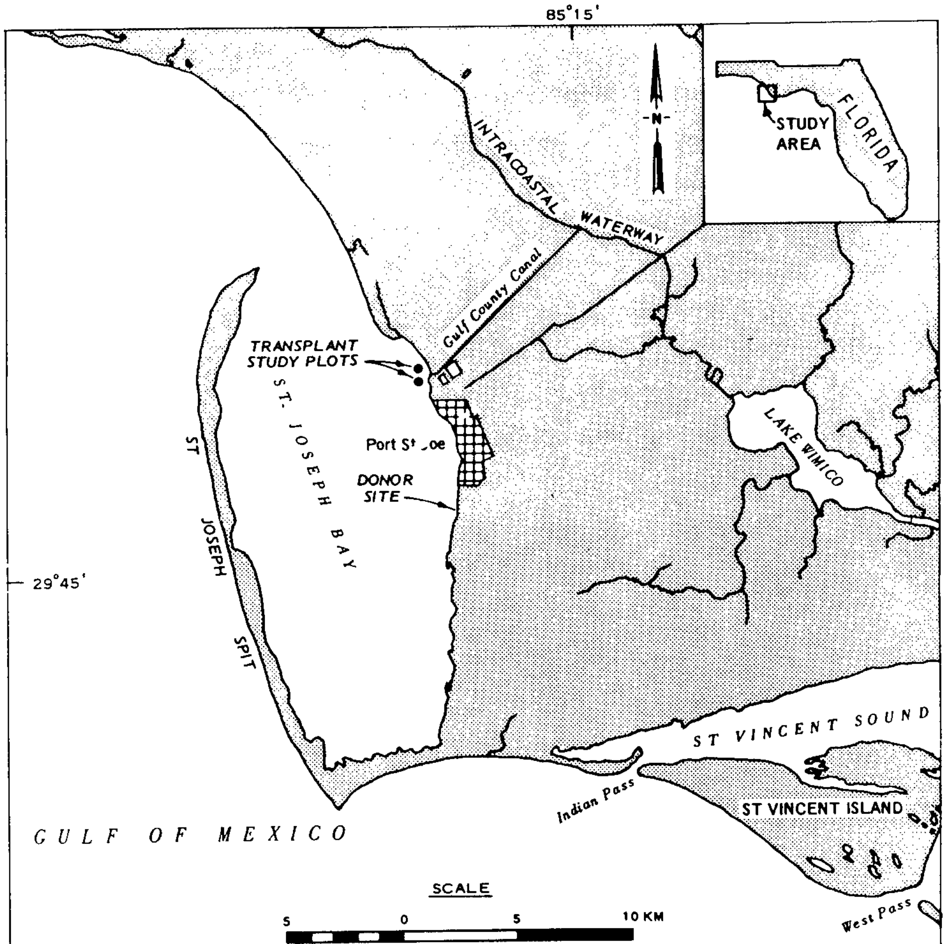


Figure 66. Location of Port St. Joe field project. Halodule wrightii donor site and transplant areas are indicated (from Phillips 1977).

2.3.2 Selected Projects

a. Marco Island. Marco Island, a Deltona Corporation development in southwest Florida, was the site of wetland habitat replacement and improvement experiments that were initiated because of the developer's desire to dredge channels and fill wetlands for community development. In 1972, two islands with a total area of 3.1 ha were created in Roberts Bay (Figure 67) during channel construction. Between 17 May 1972 and 21 May 1973, 2,458 *Rhizophora mangle* and 19 *Avicennia germinans* and *Laguncularia racemosa* were planted on the two islands (Kinch 1975). The trees ranged from 0.6 to 2.4 m in height and were planted on 0.9 m centers. The sites were monitored from 8 March 1973 to 19 November 1974 for growth rate compared to a natural site using trees of a similar size range. Mean growth rate for the transplants was less than 50% of that at the natural site. After 3 years, only 389 *R. mangle* (15.7% of the total planted) survived on the dredge spoil island. The high mortality was attributed to the fluid,

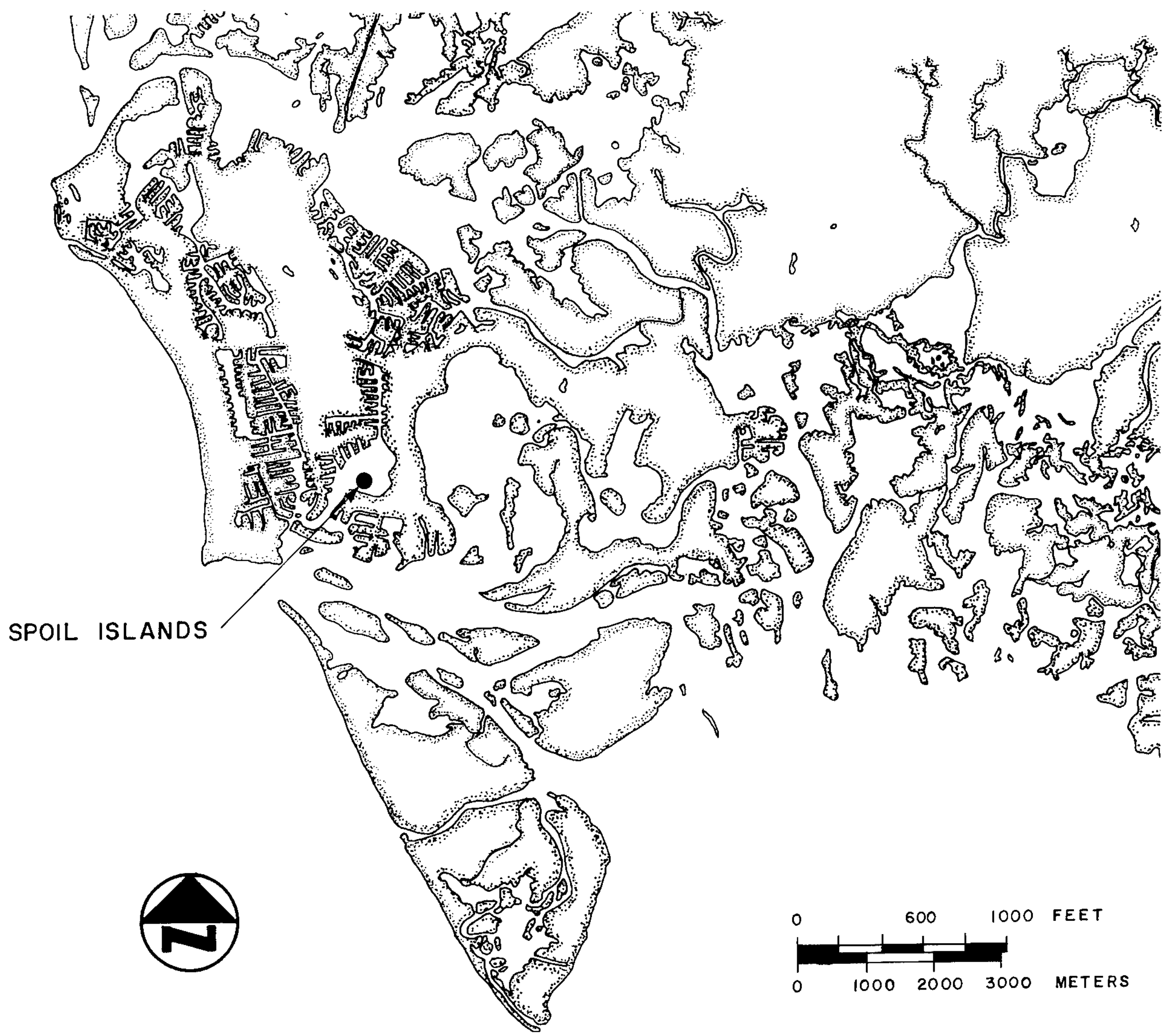


Figure 67. Location of spoil islands constructed and planted with mangroves at Marco Island (from Kinch 1975).

unconsolidated nature of the hydraulic dredge spoil (Kinch 1975). In 3 years, the island had settled and spread leaving less than 10% of the island above mean high water (Kinch 1975).

b. Tampa Bay. Within Tampa Bay, dredged material has long been considered for potential replacement of lost coastal habitat. There are two types of spoil islands in Tampa Bay: those constructed by the USACE for the purpose of maintenance spoil containment (Islands 2D and 3D), which have high diked perimeters and are constructed to serve as long-term dredged material disposal areas, not as habitat for fish and wildlife; and smaller spoil islands either left to revegetate or be revegetated by planting (e.g., Sunken, Fantasy, Fishhook Islands). Techniques for providing more wetland habitat on containment spoil islands (i.e., 2D, 3D) have recently been considered as part of the proposed dredging of the Big Bend-Alafia Channels. As part of the mitigation plan, breakwaters and riprap are proposed to be used to stabilize existing spoil islands, and dredged material is proposed to be deposited behind breakwaters to create more littoral habitat suitable for marsh development. In 1974, the TPA sponsored investigations into the use of existing spoil islands and spoil island creation to replace lost rookery habitat (Lewis and Dunstan 1974). Reports on mangrove planting on dredged material islands in Tampa Bay (Lewis and Dunstan 1976b) and plant succession on intertidal dredged material (Lewis and Dunstan 1976a) suggest that although mangrove planting in protected areas is feasible, the use of Spartina alterniflora may be more appropriate for rapid cover and stabilization because mangroves grow slowly and do not spread by rhizomes. Mangroves will probably replace S. alterniflora in the normal succession of plant communities.

An experimental planting of S. alterniflora was attempted on Fishhook Spoil (Figure 68) in Tampa Bay (Lewis and Lewis 1977). On 12 September 1976, 36 plugs of S. alterniflora were removed from a nearby marsh with a post-hole digger and placed on 1-m centers in six rows of six plants each in an elevation range of +61 to +49 cm mean low water (MLW). In addition, on 2 October 1976, 15 S. alterniflora plants grown from seeds and harvested in Virginia were planted in the area. After 10 months, the 36 plugs of native S. alterniflora exhibited a 741% increase in culm number. The Virginia plants increased 2,200% in culm number; genetic differences were suggested as a reason for the differences in vigor. The plants placed between +58 and +49 cm demonstrated the greatest success and production. Above 58 cm, they were overgrown by Paspalum vaginatum, Avicennia germinans, and Laguncularia racemosa.

Wetland restoration of littoral areas on Sunken and Fantasy Islands has been reviewed and evaluated in Chapter 1. Both projects were highly successful in the utilization of S. alterniflora, especially Sunken Island, where extensive natural recruitment by mangroves has occurred and habitat utilization by fish and wildlife appears high. Several decades, however, will be required before the mangroves reach maturity.

c. Other projects. As early as 1967, experimental planting of S. alterniflora on barren spoil areas was attempted (but not monitored) on Galveston Island, Texas (Hoagland 1968). An experimental planting of S. alterniflora and S. patens on dredged spoil on Bolivar Peninsula, Texas, was funded by the DMRP (Webb et al. 1978). Good short-term success was achieved using an expensive sandbag dike to protect the plantings from wave energy while the plants were becoming established. An experiment testing plant sources and the date of planting of S. alterniflora on dredge spoil was attempted in Corpus Christi Bay, Texas, with varying results (Oppenheimer and Carangelo 1978). August plantings were the least successful and plant source appeared to have no effect on the success of the plantings. Allen and Webb (1982) experimented with the use of several types of breakwaters to protect S. alterniflora plantings in Mobile Bay, Alabama. A temporary floating tire breakwater proved to be more effective for attenuating waves and protecting S. alterniflora plantings than a fixed (permanent) breakwater.

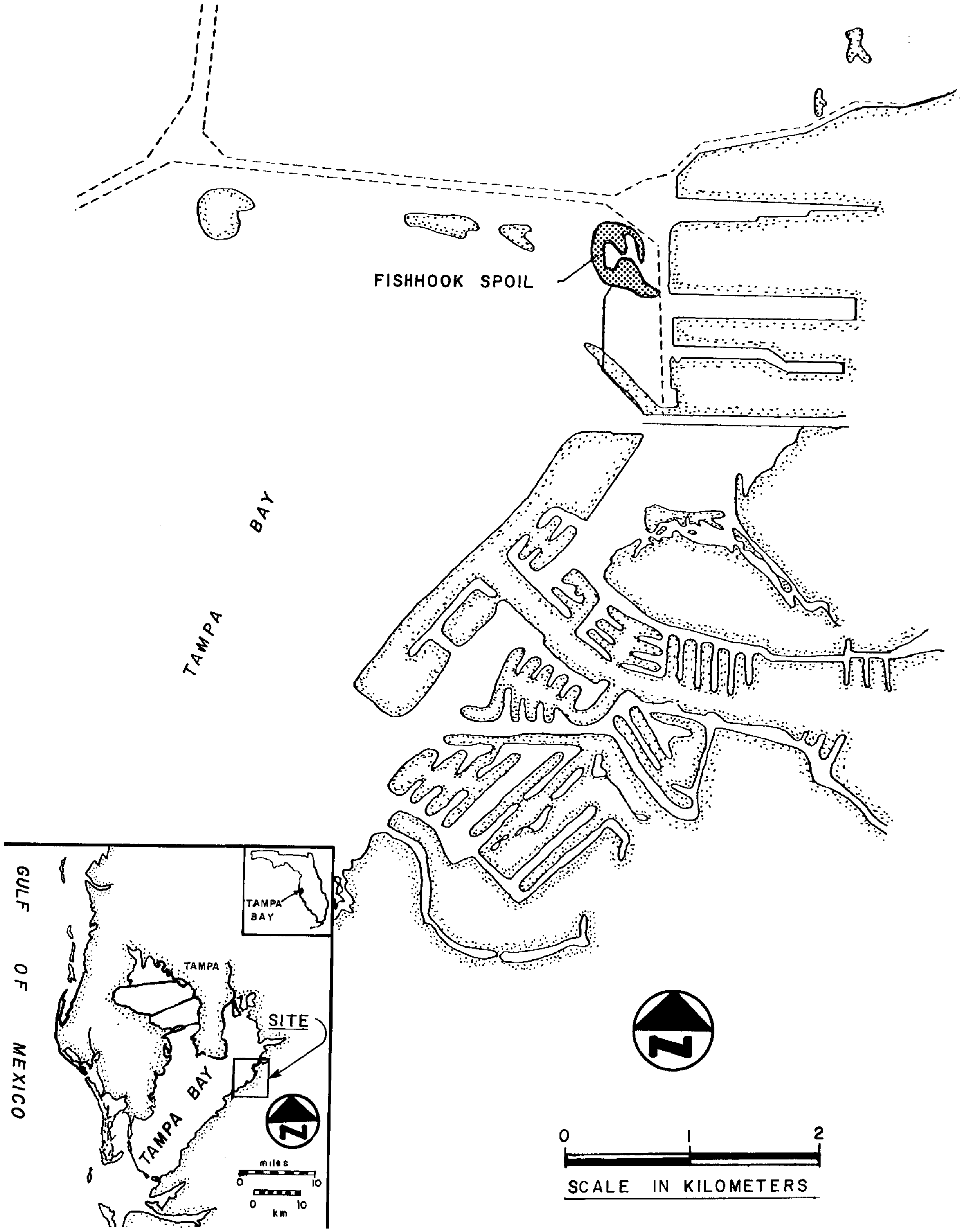


Figure 68. Study site location (Fishhook Spoil) in Lower Hillsborough Bay, Florida (from Lewis and Lewis 1977).

2.3.3 Evaluation

The beneficial use of dredged material to create new wetland habitat in areas that are isolated from normal human disruption has strong public appeal (Smith 1978). Because dredged material is an inevitable by-product of port development, it is appropriate to consider the use of the material to mitigate habitat losses resulting from that type of development. The filling of old borrow pits, nonproductive shorelines, and decommissioned channels and canals has been proposed as a means of putting dredged material to use in Tampa Bay (W. Fehring; pers. comm.). Habitats that could be created include shoreline marshes and subtidal sand flats.

The DMRP and other studies reviewed above have shown that if the proper substrate type, elevation, and protection from waves are available, wetland vegetation can be established on dredged material. However, the likelihood of success will vary depending on several variables.

The most successful use of dredged material has been in creation of salt marsh habitats; marshes can be constructed with a high degree of confidence and at a small additional cost to a project because traditional disposal techniques can be used in the process (Smith 1978). There can be problems with the use of dredged material for marsh creation, however. The spoil material may contain contaminants that could be taken up by the plants and then be released into the ecosystem through consumption by animals or decomposition. Or the material may, like the maintenance spoil from Tampa Bay, be too fine to use for spoil island creation. In the past, the maintenance spoil from the upper portion of Tampa Bay has been contained and is being disposed of in Spoil Islands 2D and 3D. Another problem is that hydrodynamically suitable (= low-energy) sites for marsh creation must be available near the source of the dredged material. If they are not, it may be necessary to transport the material to a suitable location or construct protective breakwaters around the spoil island; both alternatives involve additional costs.

The use of dredged material to create subtidal seagrass habitats, as in the Port St. Joe project, has not been successful. Plans are currently being made by the FDNR to conduct a series of experimental seagrass plantings in a subtidal area off Lassing Park, Pinellas County, which was filled with dredged material in 1983 (see Chapter 1, Section 3.2.11). The material has had over a year to consolidate and stabilize, and the proximity of naturally-occurring seagrass beds should increase the likelihood that the plantings will succeed. However, other seagrass planting efforts such as those in Biscayne Bay, reviewed in Section 2.2.3(b), have not been very successful. Moreover, seagrass coverage in Tampa Bay has been declining (Continental Shelf Associates, Inc. 1982), probably due, in part, to deteriorating water quality. Creation of new seagrass habitats is not likely to reverse this trend until the problems responsible for the decline are remedied. The trends in water quality in Tampa Bay and suggestions for potential improvement are discussed in Section 2.2.3(c).

2.4 SUMMARY AND RECOMMENDATIONS

Table 26 summarizes the feasibility of mitigation/restoration options for each habitat type discussed in Section 2.2. Also included, where applicable, are recommended planting species, techniques, approaches, potential problems, and potential uses of dredged material.

The use of *Spartina alterniflora* to create salt marshes is recommended for newly created intertidal areas such as islands or shorelines constructed from dredged material. *Juncus roemerianus* has been planted in the high marsh areas (e.g., Branches Hammock, Chapter 1, Section 1.3.7), but it is slow growing and sensitive to soil elevation. Both species can be planted relatively inexpensively as sprigs or plugs. Cost of planting can be estimated by using the estimates of Woodhouse and Knutson (1982) and applying an estimated cost per work hour. *Spartina alterniflora* is a fast-growing grass that can quickly stabilize an intertidal shoreline. Fertilizers may be required if the soil is nutrient-poor and temporary or permanent breakwaters may be needed in high-energy environments. The importance

Table 26. Feasibility of mitigation/restoration for each habitat type.

Habitat type	Feasibility of mitigation/ restoration	Recommended planting species	Recommended planting technique	Recommended approach(es)	Potential problems	Potential use of dredged material
Mangrove	Good	*Rhizophora mangle* *Avicennia germinans* *Laguncularia racemosa* (depending on site elevation)	Seeds or seedlings	Improve existing mangrove habitats; plant within existing mangrove habitats; precondition areas by planting with *S. alterniflora*	Slow growing; highly susceptible to waves, erosion, etc.; sensitive to soil conditions (nutrient contents elevation)	Not recommended unless protected from waves and human interference
Salt marsh	Good	*Spartina alterniflora* *Juncus roemerianus* (depending on site elevation)	Sprigs or plugs	Plant in newly created habitats, e.g., dredged material islands	Requires proper soil elevation; May require fertilizers; May require protection by breakwaters in high energy environments	Recommended
Seagrass	Poor	*Halodule wrightii* *Thalassia testudinum*	Plugs, shoots, or seedlings	Test planting designs with experimental plantings to identify species, location, and method of planting	Need to improve water quality	Possibly
Mud flats	Good	N/A[a]	N/A	Include in design of large mitigation/ restoration projects	Requires proper elevation and low-wave energy	Recommended
Artificial Reefs	Good	N/A	N/A	Reef should be constructed to enhance specific targeted species (e.g., lobsters, finfishes)	Inadequate monitoring of past projects to predict problems	N/A
Oyster Reefs	Good	*Crassostrea virginica*	Cultch or seed oysters	N/A	Need to improve water quality	Possibly

[a]N/A = not applicable.

of planting elevation for S. alterniflora is well documented (see Chapter 1), and this must be taken into account for a successful project. As mentioned above, in the Tampa Bay area, S. alterniflora appears to be a seral stage to mangrove forest development. After establishment, S. alterniflora tends to naturally collect floating mangrove seeds and protect the seedlings during development.

The feasibility of expanding and improving mangrove habitat containing the three species of mangroves found in Florida is good. The most cost-effective technique is to plant seeds or seedlings of the three species. Mangroves are known as shoreline stabilizers; potential problems during revegetation, however, result from the slow growth of the trees and spread of their root systems. When first planted, the mangroves are highly susceptible to erosion by waves and boat wakes. The most successful projects reviewed were mangrove plantings in regraded areas within existing mangrove forests, e.g., the Grassy Point and Windstar projects (discussed in Section 2.2.2b). The existing mangroves provide the needed protection and planting seeds or seedlings accelerates the natural revegetation process. Spartina alterniflora can provide the same protection and may be a means for preconditioning newly created intertidal areas (e.g., those created with dredged material) for planting or natural colonization of mangroves. However, a a source of mangrove seeds needs to be available for natural colonization. Optimal planting elevation for mangroves appears to be at or slightly below the level of the surrounding marsh (e.g., the Windstar project). Also existing mangrove wetlands can be improved by opening and improving connections between isolated wetland areas and the estuary. The described enhancement, however, should not be used to mitigate for loss of habitat.

It is not likely that a seagrass planting program in Tampa Bay will be successful until water quality and clarity are improved (TBRPC 1985). Before a large seagrass planting program is undertaken in Tampa Bay, an experimental planting program to identify the seagrass species, locations, and methods best suited for planting needs to be initiated. Data from the projects reviewed indicate that Halodule wrightii, because of its broad tolerance to environmental stress and pioneering features, may be the most successful species overall. Thalassia testudinum plantings have been successful, but the species is slow growing. The most successful planting methods for these species of seagrasses have been plugs, shoots, or seedlings. Because of the low survival rate of planted seagrasses and the consequent need for replanting, seagrass planting projects have proven to be expensive, e.g., Biscayne Bay and New Pass Channel (discussed in Section 2.2.3b).

Creation of the other intertidal and subtidal habitats (mud flats, artificial reefs, and oyster reefs) has not been traditionally considered as a means of estuarine mitigation, restoration, or enhancement. However, creation of these habitats should be considered as a means to attract particular species of fish and wildlife provided the habitat has been found to be limiting. Artificial and oyster reefs can be constructed to attract specific molluscs, crustaceans, and finfishes and an array of fouling organisms.

Water quality must be improved before seagrass, algal, and oyster reef communities can be expanded in Tampa Bay (TBRPC 1985). Creation of wetlands, which are known to sequester nutrients and retard upland runoff, may help to reverse the historical decline in water quality in Tampa Bay. Limitations exist as to the acceptance of creation of wetlands for water quality improvements. The USFWS accepts mitigation that creates fish and wildlife habitat; the EPA may be more interested in improving water quality than creating habitat; and the FDER currently has no policies on mitigation or creation of wetlands, but approaches the matter on a case-by-case basis.

Many studies have linked the food webs of wetland habitats to ecologically and commercially important animal species. Analysis of historical trends of the populations of these species in wetland habitats in Tampa Bay is needed in order to prioritize the desired habitats for a

large-scale restoration program and to give direction to the question of placement (location and size). The feasibility options recommended in this chapter, along with an understanding of historic habitat losses and desired needs, should form the basis for development of a bay-wide restoration and/or enhancement program for Tampa Bay.

CHAPTER 3. POTENTIAL MITIGATION SITES IN TAMPA BAY

3.1 TECHNICAL APPROACH

Chapter 3 tasks included selection and field evaluation of potential mitigation sites for projects involving necessary unavoidable loss and preparation of site summaries and map overlays. Before these sites are used as mitigation sites, additional study is needed to determine what types of projects the site would be acceptable for and how much compensation the project would provide. These studies should be coordinated with the USFWS, FDER, and other agencies having the responsibility of approving mitigation plans.

Criteria for site selection were developed during the post-award meeting with the USFWS. Mitigation sites were to be selected so as to:

1) maximize habitat diversity both locally and regionally;
2) increase habitat in each area that has been degraded by human activities;
3) maximize habitat in areas that support particularly important or sensitive species; and
4) maximize the probability of success.

Forty-six potential sites were identified through photointerpretation of the 1982 1:24,000 color photographs of Tampa Bay and discussions with local experts. Preliminary screening of potential sites was accomplished during the USFWS TPA workshop held 9 April 1985. Following this screening, 27 sites remained for consideration. The final list was reviewed and modified based on the size and location of the prospective sites.

Field investigations were conducted at 19 sites (Table 27). Information compiled for each site included location, topography, sediment and soil characteristics, land use, existing habitat types and associated plant and animal species, water quality, and feasible mitigation options. Representative color slides and black-and-white photographs were taken at each site. Only 13 sites appeared suitable for habitat creation projects or involved adequate acreage for consideration. The final sites for which map overlays and site narratives were prepared are indicated in Table 27 and locations are shown in Figure 69.

3.2 SITE EVALUATIONS

3.2.1 Hillsborough Bay

a. Delaney pop-off canal to the Alafia River. Site Description: This site consists of two areas (Figures 69 and 70): (1) the Delaney pop-off canal, and (2) the shoreline west of the Gardinier, Inc. gypsum pile.

The Delaney pop-off canal (Figures 70 and 71) is a drainage canal cut through the extensive wetlands area extending south to the Gardinier, Inc. gypsum pile, east to Route 41 (and beyond in areas) and west into Hillsborough Bay. The spoil berms created during channel construction have impounded portions of the marsh, preventing exchange with the tidal waters of Hillsborough Bay. A fringe of mangroves, predominantly *Avicennia germinans* and *S. alterniflora*, presently exists along the spoil banks. Fishes and wildlife observed during our 12 June 1985 field survey are listed in Table 28.

Table 27. Potential mitigation sites in Tampa Bay.

Location		Region of bay
Pendola Point[a] to Alafia River		Hillsborough Bay
3-D Spoil Island		Hillsborough Bay
2-D Spoil Island		Hillsborough Bay
Port Redwing Basin		Hillsborough Bay
McKay Bay		Hillsborough Bay
MacDill Area		Hillsborough Bay
Delaney Creek[a]		Hillsborough Bay
Bayshore Area[a]		Hillsborough Bay
Channel A		Old Tampa Bay
Booth Point		Old Tampa Bay
St. Petersburg-Clearwater Airport		Old Tampa Bay
Weedon Island[a]		Old Tampa Bay
West end Howard-Frankland Causeway		Old Tampa Bay
Kaul Fill site		Old Tampa Bay
Sheldon fill site and borrow pit[a]		Old Tampa Bay
Port Tampa to Gandy Blvd.[a]		Old Tampa Bay
Largo Inlet[b]		Old Tampa Bay
Lake Tarpon Channel[b]		Old Tampa Bay
Alligator Lake[b]		Old Tampa Bay
Maximo Channel[a] Coffee Pot Bayou[b]	Both in	Lower Tampa Bay, North Side
E.G. Simmons Park[b] Cockroach Bay[a]	Both in	Lower Tampa Bay, South Side
Port Manatee area[a] Perico Bayou Bishop Harbor[b] Manatee River-Palmetto, Ellenton[b]	All in	Port Manatee and Manatee River area

[a]Omitted from consideration as a mitigation site following field investigations and consultations.
[b]Omitted from consideration as a mitigation site following evaluations for size and location of site.

The Gardinier, Inc. gypsum pile (Figure 70) was constructed predominantly on bayland, and a small fringe of wetlands has developed to the west of the pile (Figure 72). The gypsum pile has been a constant source of acidic waters; fluoride, phosphate, and radionuclide enrichment; and fine particulate material pollution to the bay.

Land use: The TPA owns the submerged lands to the Alafia River. Gardinier, Inc. owns the upland property in the vicinity of the Delaney pop-off canal. The only planned land use of the area is the eventual decommissioning of the gypsum pile by Gardinier, Inc.

Mitigation plan: A mitigation plan was proposed for the Delaney pop-off canal by the TPA. It proposes to dechannelize the canal by excavating and revegetating the spoil berms. The mitigation action for the Gardinier shoreline is to fill 60+ m bayward to MSL and plant with *S. alterniflora* to increase the amount of

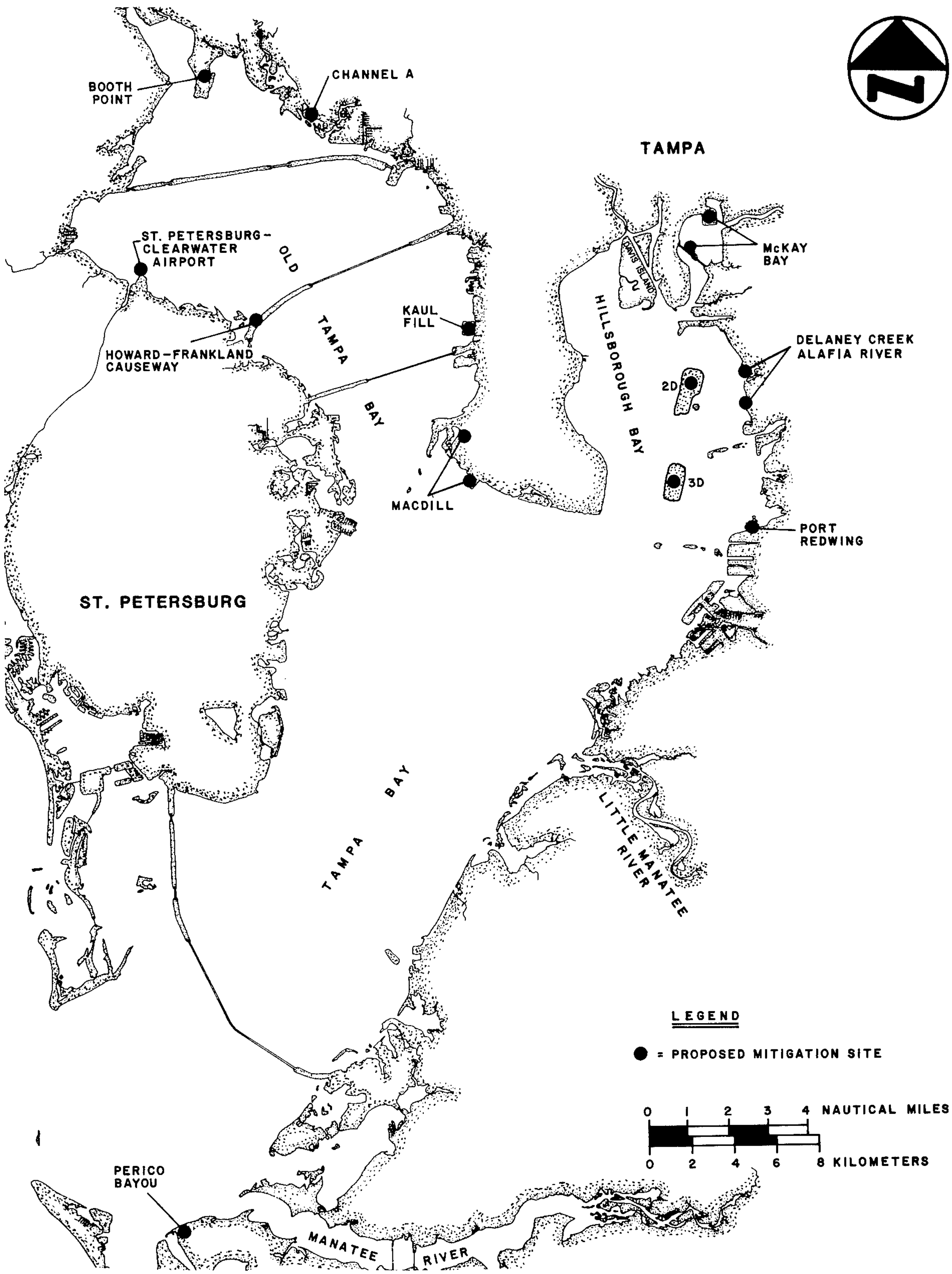


Figure 69. Locations of proposed mitigation sites in Tampa Bay.

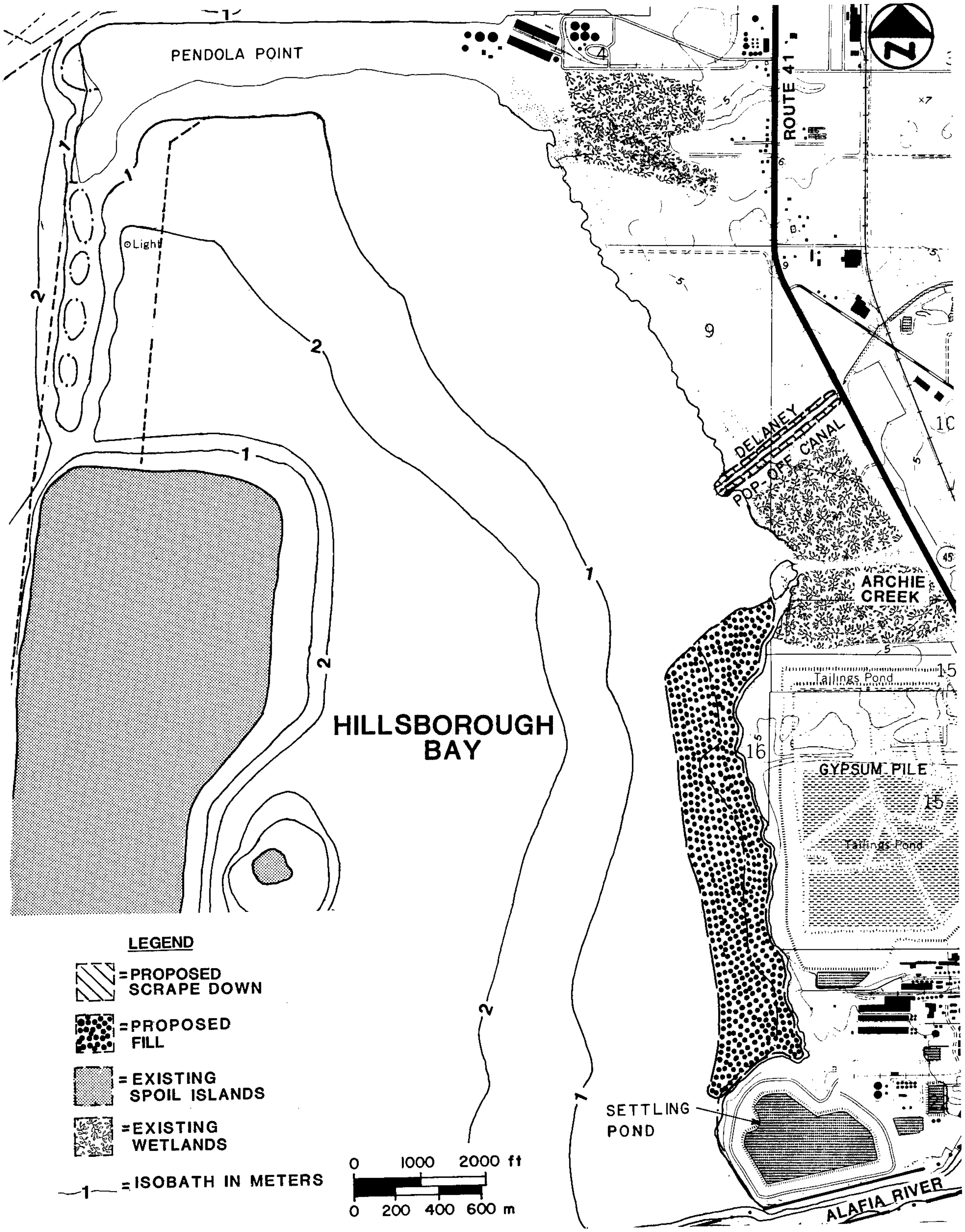


Figure 70. Map of the Delaney pop-off canal and the Alafia River mitigation sites. Adapted from Kunneke & Palik 1984.

Figure 71. Fringing marsh and uplands at the mouth of the Delaney pop-off canal.

Figure 72. Shoreline near Gardinier, Inc. gypsum pile with fringing *Spartina alterniflora* marsh, drift algae (*Ulva* sp.), and freeze-damaged mangroves.

Table 28. Organisms observed during the 12 June 1985 field survey of the Delaney pop-off canal and the Gardinier shoreline conducted by Continental Shelf Associates, Inc.

Species Name	Common name
Fishes:	
Strongylura marina	Atlantic needlefish
Anchoa mitchilli	Bay anchovy
Caranx hippos	Crevalle jack
Birds:	
Eudocimus albus	White Ibis
Ardea herodias	Great Blue Heron
Casmerodius albus	Great Egret
Agelaius phoeniceus	Red-winged Blackbird
Invertebrates:	
Geukensia demissus	Ribbed mussel
Littorina irrorata	Marsh periwinkle
Uca spp.	Fiddler crabs

salt marsh in Hillsborough Bay (Figure 70). This action would have the dual purpose of increasing habitat and improving water quality in the bay. However the habitat value of the benthic habitats may prevent or limit filling in shallow bay bottom and this needs further evaluation before such a trade-off is permissible. The proposed plan for this area will result in the filling of 65 ha of bay bottom and borrow pits and the scraping down of 2 ha of upland.

b. Spoil Island 2-D. Site Description: Spoil Island 2-D is a large (>220 ha) diked island located north of the channel to the Alafia River and east of the channel to Hookers Point (Figures 69 and 73). The island, constructed largely of coarse limestone rock and rubble, was built in 1978 by the USACE for spoil containment as a part of the Tampa Harbor deepening project. In 1979, an attempt was made to plant the eastern shoreline of the island with *Spartina patens* and *S. alterniflora* (Figure 74).

During our survey, we observed that the *S. alternifora* had become established on only the northeastern end of the island. Mangroves, predominantly *Avicennia germinans*, have become

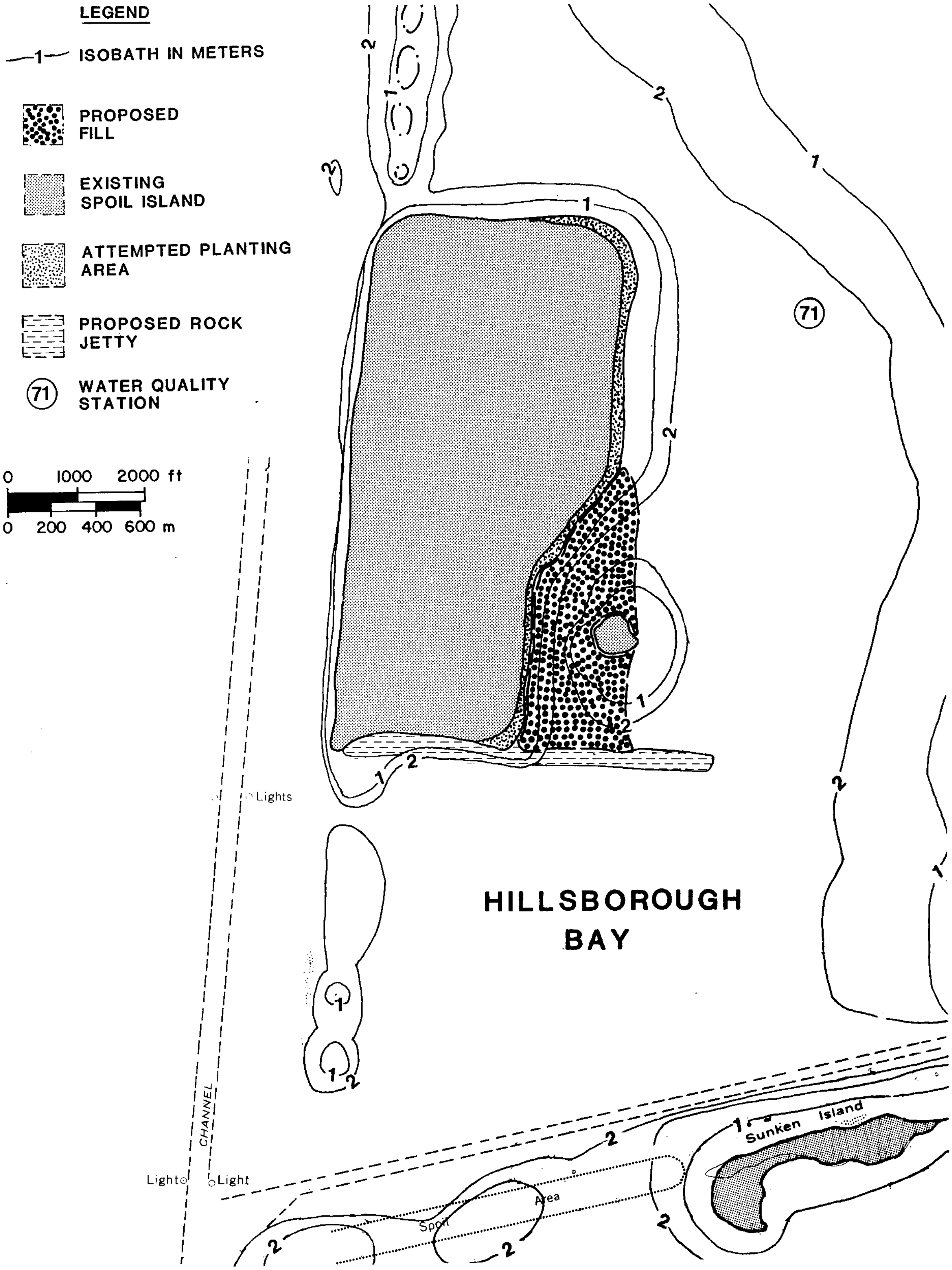


Figure 73. Site map of the Spoil Island 2-D mitigation site (adapted from Kunneke and Palik 1984).

Figure 74. Eastern shoreline of Spoil Island 2-D showing Spartina patens marsh and upland vegetation.

established in the area. Spartina patens, however, forms a 6- to 15-m wide band along a shelf waterward of the containment dike (Figure 74). Paspalum vaginatum has become established landward of the S. patens, and Iva fruitescens grows on the sides and top of the containment dike. Grasses and shrubs have invaded the interior of the containment area.

Water quality in the vicinity of Spoil Island 2-D has been reported and averaged for a period from September 1978 to August 1983 (HCEPC, in press). Station No. 71 is located northeast of the island; Station No. 55, south of the island and north of the Alafia channel; and Station No. 8, southeast of the island and north of the Alafia channel (Figure 73). Five-year average values for the measured water quality parameters are reported in Table 29. As is true for most of Hillsborough Bay, the data indicate elevated chlorophyll, nitrogen, and turbidity levels in the area.

Bird usage of the island has been extensive. The island contains probably the largest Laughing Gull colony in the State (Figure 75), with numbers conservatively estimated at 20,000 pairs in 1984 (S. R. Patton and L. A. Hanners, pers. comm. in Lewis and Paul, in press). Nests of Least Terns (Sterna albifrons) and Black Skimmers (Rynchops nigra) were seen on the island in 1979 and in 1981, the colonial nesters were Gull-billed Terns (Gelochelidon nilotica) (4 pairs), Least Terns (60+ pairs), and Black Skimmers (200 pairs) (Lewis and Paul, in press). American Oystercatchers (Haematopus palliatus), Black-necked Stilt

Table 29. Five-year (1978-83) average values for water quality parameters at stations in the vicinity of Spoil Island 2-D (from HCEPC, in press).

Water quality parameter	Annual average values: Station 71	Station 55	Station 8
Total chlorophyll (μg/l)	44.4	40.0	46.6
Conductivity (μmhos)	37,271	38,471	37,400
Turbidity (NTU)	9.5	5.5	6.6
Temperature (°C)	23.9	23.6	23.6
Total nitrogen (mg/l)	1.12	0.96	1.12

Figure 75. Laughing gull colony on top of dike on east side of Spoil Island 2-D.

(Himantopus mexicanus) Wilson's Plover (Charadrius wilsonia), and Snowy Polver (Charadrius alexandrinus) were also noted (Lewis and Paul, in press). Because of the marginal nature of the wetlands on the east side of the island, few fishes are able to use the wetland areas surrounding the island.

Land use: The USACE plans to use Spoil Islands 2-D and 3-D for the next 25 to 35 years. The islands have been estimated to contain sufficient capacity for the maintenance of the main ship channel northeast of the Gadsden Point widener and the inner harbor branch channels for that period. The TPA owns the surrounding submerged lands.

Mitigation plan: A mitigation plan has been proposed by the Tampa Bay Management Study Commission for the Tampa Harbor, Alafia River, and Big Bend Channel deepening project. The mitigation would have two objectives: (1) to create habitat for waterfowl and shorebirds, and (2) to lessen erosion of the island and the related water quality problems. The plan would require riprap erosion protection for the southern, western, and northern shores of the island and extend the southern riprap eastward to form a rock jetty in order to provide conditions necessary for the proposal mitigation. The Study Commission's plan calls for creation of 9 ha of marsh. Our recommendation is to fill approximately 50 ha of bay bottom to +1.0 NGVD on the eastern side of the island (Figure 76) and plant with Spartina alterniflora at a minimum of 1-m centers. The proposed fill area is presently approximately 2 to 3 m in depth, and the slope from the shoreline to bay bottom is steep. However, the value of the subtidal habitat would have to be determined before filling could be recommended. The proposed rock jetty would protect the planting area from erosion.

c. Spoil Island 3-D. Site Description: Spoil Island 3-D is a large (approximately 150 ha) diked island located immediately east of the channel to Hooker's Point, south of the channel to the Alafia River, and north of the channel to Port Redwing (Figures 69 and 77). The island, constructed largely of sand and fine shell, was built in 1981 by the USACE for spoil containment as a part of the Tampa Harbor deepening project. No vegetation has been planted on the island, which is eroding rapidly (Lewis and Paul, in press). Observations during our survey indicate that the entire island base is eroded at the southwest corner, forming a 6-m cliff from the eroded dike. The

Figure 76. Vegetational zonation on Spoil Island 2-D with area of proposed fill in the foreground.

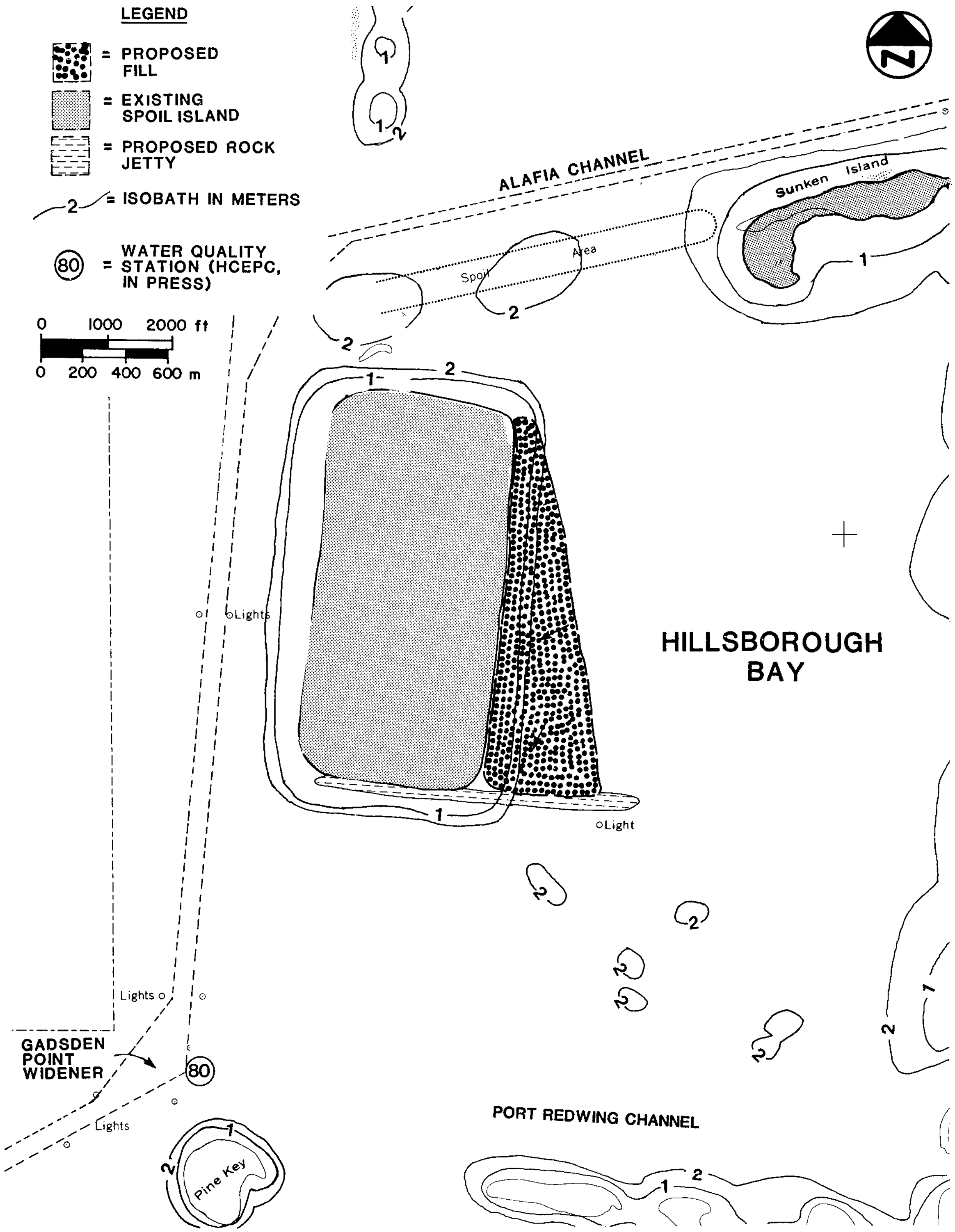


Figure 77. Map of the Spoil Island 3-D mitigation site (adapted from Kunneke and Palik 1984).

eastern shoreline, however, has a 6- to 10-m shelf between the dike base and the MHW line (Figures 78 and 79). This area has become vegetated with grasses [e.g., Paspalum vaginatum and Ipomea pes-caprae (railroad vine)]. The interior of the island is only partially vegetated with grasses and low shrubs (Figure 80). Sprigs of seagrasses (Halodule wrightii and Thalassia testudinum) were observed during our survey in the surf zone on the eastern side of the island.

Water quality near Spoil Island 3-D has been reported and averaged for a period from September 1978 to August 1983 (HCEPC, in press). Station No. 80 is located on the eastern side of the Gadsden

Figure 80. Spoil Island 3-D and associated upland vegetation.

Figure 78. View of eastern side of Spoil Island 3-D showing narrow littoral zone.

Figure 79. Southeastern side of Spoil Island 3-D showing narrow littoral zone.

Point widener, north of the channel to Port Redwing and Station No. 73, east of the spoil island (Kunneke and Palik 1984). The five-year average values for the measured water quality parameters are reported in Table 30. The data indicate a similar elevation of the chlorophyll, turbidity, and total nitrogen values as was found for most of Hillsborough Bay.

Colonial bird use on Spoil Island 3-D has been documented by Lewis and Paul (in

Table 30. Five-year (1978-83) average values for water quality parameters at stations in the vicinity of Spoil Island 3-D (from HCEPC, in press).

Water quality parameter	Annual average values: Station 80	Annual average values: Station 73
Total chlorophyll (μg/l)	35.8	40.8
Conductivity (μmhos)	40,396	39,025
Turbidity (NTU)	4.8	5.9
Temperature (°C)	23.6	23.6
Total nitrogen (mg/l)	0.92	1.14

press). Since 1982, the barren sand dikes have been used by 400 nesting pairs of Black Skimmer (Rynchops nigra) and 50 to 60 pairs of Least Tern. In 1984, Caspian Tern (Sterna caspia) numbered 45 pairs, the largest colony ever in Florida for this species, and 200 pairs of Laughing Gull (Larus atricilla) were observed. Other species observed nesting in small numbers included Gull-billed Tern (Gelochelidon nilotica), American Oystercatcher (Haematopus palliatus), Black-necked Stilt (Himantopus mexicanus), Wilson's Plover (Charadrius wilsonia), and possibly Snowy Plover (Charadrius alexandrinus). As at Spoil Island 2-D, there are many migrant shorebirds but few waterfowl because of the lack of wetland habitat.

Land use: Future land use of Spoil Islands 2-D and 3-D was discussed in Section 3.2.1.b. The TPA owns the submerged lands surrounding Spoil Island 3-D.

Mitigation plan: A mitigation plan has been proposed by the Tampa Bay Management Study Commission for the Tampa Harbor, Alafia River, and Big Bend Channel deepening project. The proposal is similar to the one for Spoil Island 2-D. The eastern shoreline of Spoil Island 3-D drops off quickly to a water depth of 3 to 4 m. The proposal is to provide riprap erosion prevention for the southern, western, and northern shorelines of the island to slow the ongoing severe erosion. The spoil islands of the channel to Port Redwing provide minimal protection to the island; therefore, a jetty extending eastward from the southern edge of the island would provide protection for a filling and Spartina alterniflora planting project similar to the one proposed for Spoil Island 2-D (Figure 77). The project could result in the creation of up to 50 ha of marsh/mangrove habitat; however, as with all shallow subtidal fills, the value of the subtidal benthic community would have to be considered before proceeding with a plan.

d. Port Redwing. Site description: Port Redwing is located in the Big Bend area of Tampa Bay on the western shoreline, at the entrance to Hillsborough Bay (Figures 69 and 81). The recent (9 March 1984) Big Bend Study by the TPA for the Coastal Energy Impact Program describes in detail the area around Port Redwing (NUS Corporation et al. 1984). The areas of concern for this study are the northern shoreline of Port Redwing and two old dredge cuts north of the port in the vicinity of Whiskey Stump Key and Green Key (two natural islands which are National Audubon Society Sanctuaries). The northern shoreline of Port Redwing currently has a 6- to 15-m fringe of Spartina alterniflora and mangroves (predominantly Avicennia germinans). Green Key is a low-lying mangrove key. Whiskey Stump Key has slightly higher elevation with a perimeter of marsh and mangroves. Both old dredge cuts, located west of and between Whiskey Stump Key and Green Key, are approximately 3 m deeper than the surrounding bottom.

Water quality in the area north of Port Redwing was evaluated extensively in 1983 during the Big Bend Study (NUS Corporation et al. 1984). Station D, located in the borrow pit west of Whiskey Stump Key, was sampled on alternate months during January through November 1983. Station E, located in the borrow pit between the two keys, was sampled periodically for in situ dissolved oxygen concentrations. The study found frequent low dissolved oxygen values within the two borrow pits, with the lowest dissolved oxygen value noted at Station D. All other water quality parameters studied were within normal ranges.

Because the two islands are National Audubon Society Sanctuaries, bird usage has been recorded extensively. Green Key was a major nesting area for wading birds, pelicans, and cormorants from the 1920's until the early 1960's (NUS Corporation et al. 1984). Extensive filling around the islands in the middle to late 1960's and freeze damage to the mangroves on Green Key in the early 1960's caused movement of the colonial nesting birds to Bird Island and the then newly created Sunken Island (Lewis 1977). During the 1983 Big Bend Study, four shoreline areas were studied for bird usage: (1) the north Redwing shoreline, (2) Fishhook Spoil, (3) Whiskey Stump Key, and (4) Green Key. The Redwing shoreline was found to have high bird usage but no nests. Whiskey Stump and

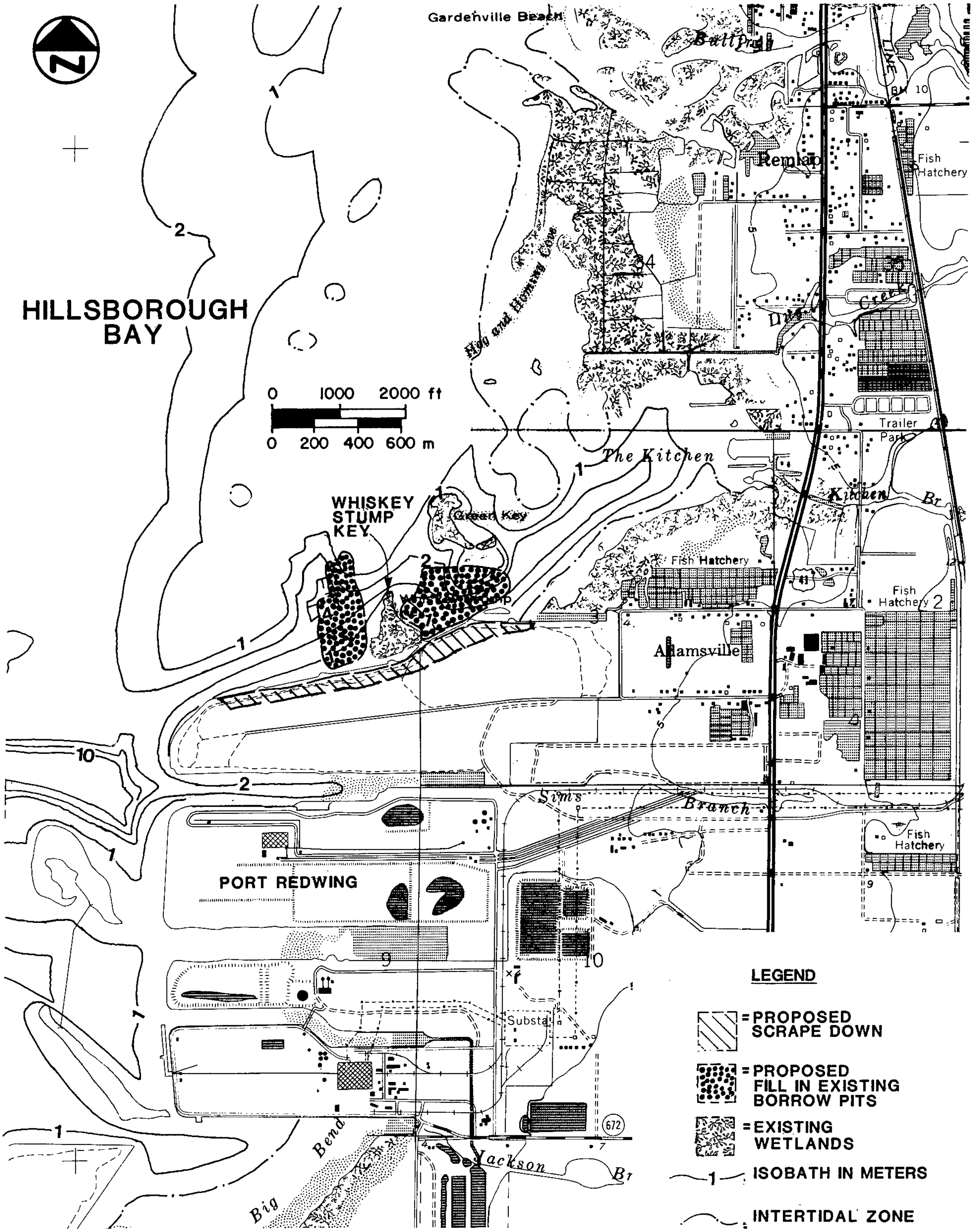


Figure 81. Map of the Port Redwing mitigation site (adapted from Kunneke and Palik 1984).

Green Key both had low but consistent bird usage. Whiskey Stump Key had nine pairs of Green Herons (Butorides striatus) nesting in the mangrove fringe on the east side of the island, whereas Green Key had no colonial bird nesting activity.

Land use: Port Redwing has plans to expand port facilities. Owners of the land considered for mitigation actions are: north side of Port Redwing--Port Redwing, Inc.; Green and Whiskey Stump Keys--the National Audubon Society; and the submerged borrow pits--the TPA.

Mitigation plan: The mitigation plan is as proposed in the Big Bend Study (NUS Corporation et al. 1984). The problems of poor water quality in the old submerged borrow pits and decreased bird usage on Whiskey Stump and Green Key were identified in the study. The northern shoreline of Port Redwing would be scraped down to MSL and planted with Spartina alterniflora to increase the potential forage and nesting areas for certain colonial bird species (Figure 81). According to the mitigation plan in the Big Bend Study (NUS Corporation et al. 1984), approximately 7.2 ha are available for scrape-down and planting. The submerged borrow pits could also be filled to the same (or a shallower) depth as the surrounding bottom to alleviate the water quality problem caused by the pits. The borrow pits occupy an approximately 8-ha area. An additional benefit of filling would be that the bottom would be raised into the euphotic zone, which could encourage the growth of algae and seagrasses. One potential problem that needs evaluation is the amount of sedimentation upstream from the borrow pits and a determination that filling these may not lead to increased turbidity in this region.

e. McKay Bay. Site Description: McKay Bay is a small (4 km^2) sheltered embayment in the northeast portion of Hillsborough Bay (Figures 69 and 82). Some areas have been dredged to 3.7 to 4.5 m depth, but most of the bay is very shallow (<1.5 m depth) (Lewis and Courser 1972). The sediment is fine sand and silt (Taylor et al. 1970).

The bay receives freshwater from the Palm River/Tampa Bypass Canal and tidal flood waters from Hillsborough Bay via East Bay and the Port of Tampa. Tidal flow through the bay and freshwater outflow are constricted by the 22nd Street Causeway; the flow in the canal is controlled by structures.

The water quality of McKay Bay and the surrounding area has been reported and averaged for a period from September 1978 to August 1983 by the HCEPC. Station No. 58 is located within McKay Bay; Station No. 54 at the 22nd Street Causeway; and Station No. 109 at the 50th Street bridge on the Palm River (Figure 82). Five-year average values for the measured water quality parameters are reported in Table 31. The mix between the saline waters of Hillsborough Bay and the less saline waters of the Palm River can be seen in the reported water quality values. Price and Schlueter (1985) report a periodic substantial reduction in salinity in McKay Bay as a result of the opening of the control structure in the Tampa Bypass canal to the Palm River.

Fish and wildlife usage of McKay Bay has been reported for birds and fishes. Lewis and Courser (1972) and Courser and Lewis (1975) reported that the mangroves, mud flats, and waters of McKay Bay are important to migrant and wintering shorebirds and waterfowl. Paul and Woodfenden (1984) reported that McKay Bay may be one of the most important wintering areas for shorebirds in the United States; a winter average count of 25,000 birds per day was reported, of which half were shorebirds. Price and Schlueter (1985) sampled the fishes and found 10 dominant species: tidewater silverside (Menidia peninsulae), striped mullet (Mugil cephalus), longnose killifish (Fundulus similis), bay anchovy (Anchoa mitchilli), spot (Leiostomus xanthurus), scaled sardine (Harengula jaguana), pinfish (Lagodon rhomboides), sheepshead minnow (Cyprinodon variegatus), gulf killifish (Fundulus grandis), and blackdrum (Pogonias cromis). The authors reported that, "although McKay Bay is environmentally stressed, it provides a rearing and developmental area for a number of commercially important fish

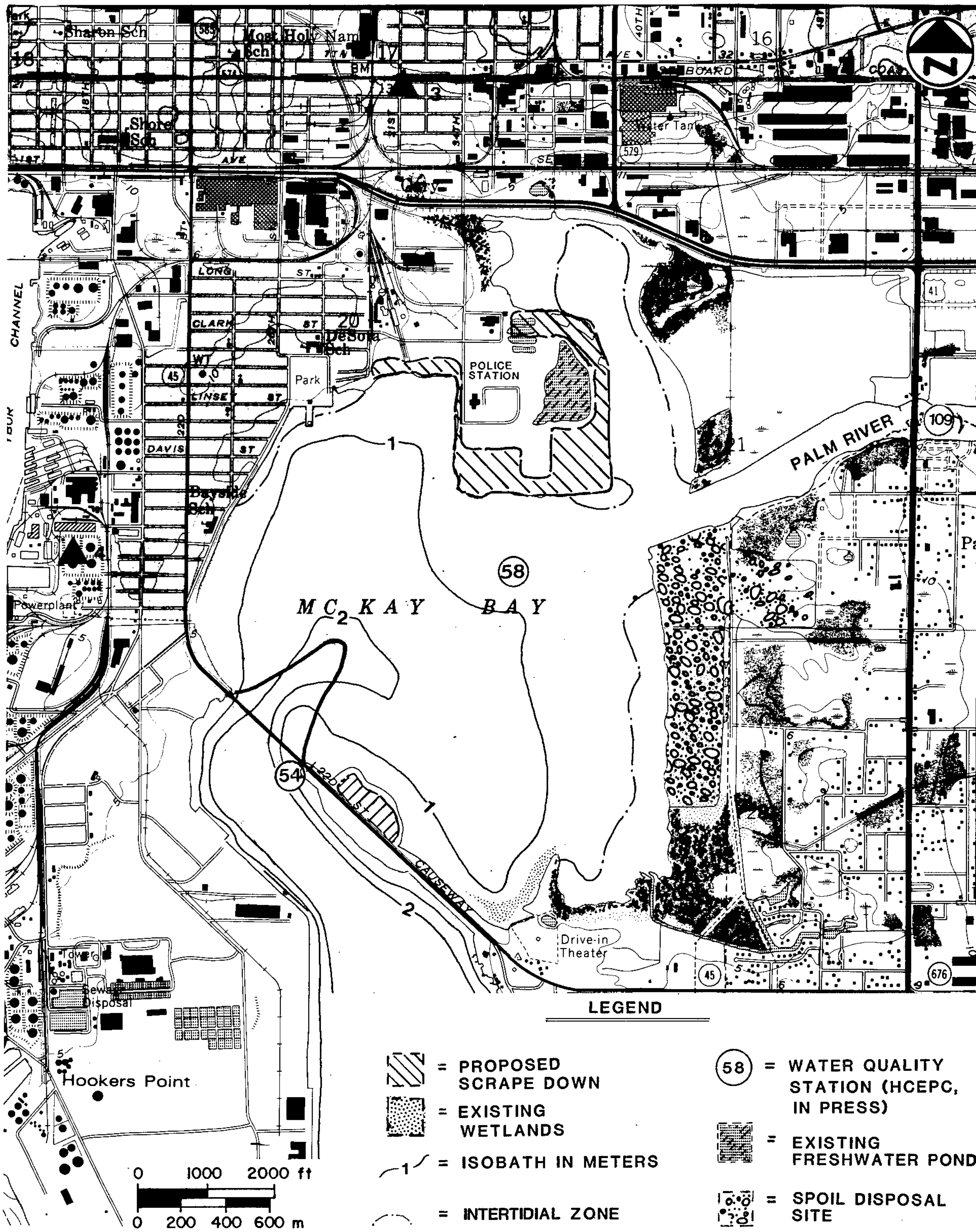


Figure 82. Map of the McKay Bay mitigation sites (adapted from Kunneke and Palik 1984).

Table 31. Five-year (1978-83) average values for water quality parameters at stations in the vicinity of McKay Bay (from HCEPC, in press).

Water quality parameter	Annual average values		
	Station 54	Station 58	Station 109
Total chlorophyll (μg/l)	31.4	49.8	41.3
Conductivity (μmhos)	38,531	35,360	23,399
Turbidity (NTU)	4.2	6.3	3.6
Temperature (°C)	24.0	24.0	23.1
Total nitrogen (mg/l)	1.09	1.20	1.32

species as well as many forage species that serve as food for marketable ones."

Land use: Current ownership of land around McKay Bay is identified in TBRPC (1985). The TPA owns all of the submerged land and some of the upland in McKay Bay. Approximately 50% of the shoreline is in public ownership. The area east of the resource recovery project is disturbed wetlands/uplands with ponded areas (Figure 83). The area south of the City of Tampa Police Department currently appears to be a spoil area littered with construction debris (Figure 84). The Southwest Florida Water Management District site is currently being diked and excavated for use as a spoil disposal site.

Mitigation plan: Issue No. 24 in The Future of Tampa Bay (TBRPC 1985) is the development of a management plan for McKay Bay. The plan proposes designation of the bay as a marine sanctuary and management by a public agency.

Large areas of land (26 ha) south of the police department and east of the resource recovery plant could be scraped

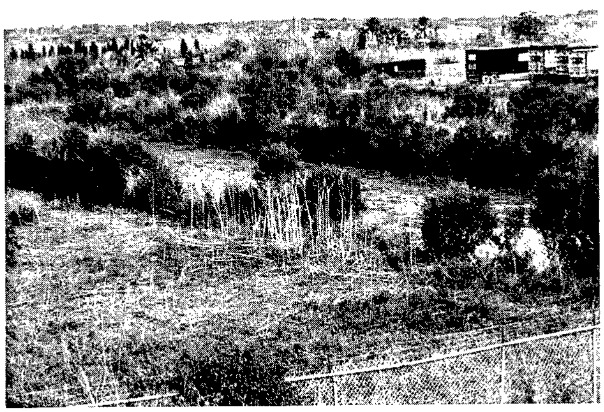


Figure 83. Disturbed upland and retention pond east of the resource recovery plant facility in McKay Bay.

Figure 84. Upland dump located south of the police training facility in upper McKay Bay.

down and planted with S. alterniflora and/or mangroves (Figure 82). However, the pond and its associated wetland habitats should be left remaining since this provides important wildlife habitat and the mitigation plan should ensure its continued health. Along the 22nd Street Causeway, there is an area of 4 ha that could be scraped down and planted.

f. MacDill area. This site consists of two areas (Figures 69 and 85): (1) two old dredged borrow pits located off the south end of the MacDill Air Force Base (AFB) runway, and (2) an area of disturbed uplands and transitional wetlands located northwest of the MacDill property and southeast of Port Tampa.

The MacDill borrow pits were dredged to provide fill material for the expanded approach for the runway. Both of these pits average 3 to 5 m in depth and the substrate consists of fine sand with an overburden of silty sand. Although no submerged aquatic vegetation exists within these areas, seagrasses and drift algae presently occur on the shallow subtidal areas adjacent to the borrow pits (CSA 1983). The bathymetry for the borrow pits and surrounding area is depicted in Figure 85. Water quality data exist for Station No. 13 (HCEPC, in press) which is over 2.8 km south-southeast of the MacDill runway terminus. Five-year (September 1978 to August 1983) average annual values for selected parameters are reported in Table 32. No water quality data have been collected within the borrow pits.

Fish and wildlife usage of the borrow pits is probably minimal. The fish community commonly found in this area is defined by Schomer et al. (in prep.) as an Estuarine Bay Fringing community. Conspicuous fish species inhabiting the shallower areas would include pinfish (Lagodon rhomboides), bay anchovy (Anchoa mitchilli), striped mullet (Mugil eephalus), mojarras (Gerridae), spot (Leiostomus xanthurus), pigfish (Orthopristis chrysoptera), herrings (Harengula spp.), pipefish (Syngnathus spp.), and gobies (Gobiidae).

The upland area is located adjacent to the northwest corner of the MacDill property (Figure 85) and includes 13 ha of disturbed upland and transitional wetlands habitat. The vegetational communities observed during our survey of the site consist of a mosaic of an "old field" stage of grasses and forbs and a pioneer scrub stage, characterized by Lantana sp., groundsel (Baccharis haliminifolia), vines and forbs and remnants of an old cabbage palm hammock, pine flatwoods, and low lying patches of Juncus roemerianus. Invasion by brazilian pepper (Schinus terebinthifolius) has been substantial throughout most of the area. An old pipeline right-of-way and access road are sparsely vegetated with salt pan plant species and stunted black mangrove. A small spoil mound at the northwest end of the right-of-way is covered with brazilian pepper. Mature mangrove habitats and extensive salt barrens border this site to the south and west. These areas are ditched by a network of small tidal creeks with adjacent spoil mounds.

Birds observed during our field survey in wetlands adjacent to this site included White Ibis (Eudocimus albus), Short-billed Dowitcher (Limnodromus griseus), Red-winged Blackbird (Agelaius phoeniceus), and Great Egret (Camerodius albus). Large populations of fiddler crabs (Uca spp.) were observed along the pipeline right-of-way. Fish utilization in the tidal creeks adjacent to the upland site consists largely of euryhaline killifishes and live bearers.

Land use: The two borrow pit sites are owned by the TPA with the majority of the site, including the pipeline right-of-way, owned by the Atlantic Land and Improvement Corporation. This site is presently undeveloped and used for unauthorized dumping of trash and garbage. Adjacent land use includes the military operation at MacDill AFB and residential development north and east of the site. Industrial and commercial operations exist northwest of the site at Port Tampa.

Mitigation plan: The goals of the proposed mitigation plan for these two areas are to provide a more suitable subtidal habitat for fish and to create more marsh habitat.

To accomplish the first goal, the elevation of the two borrow pits could be

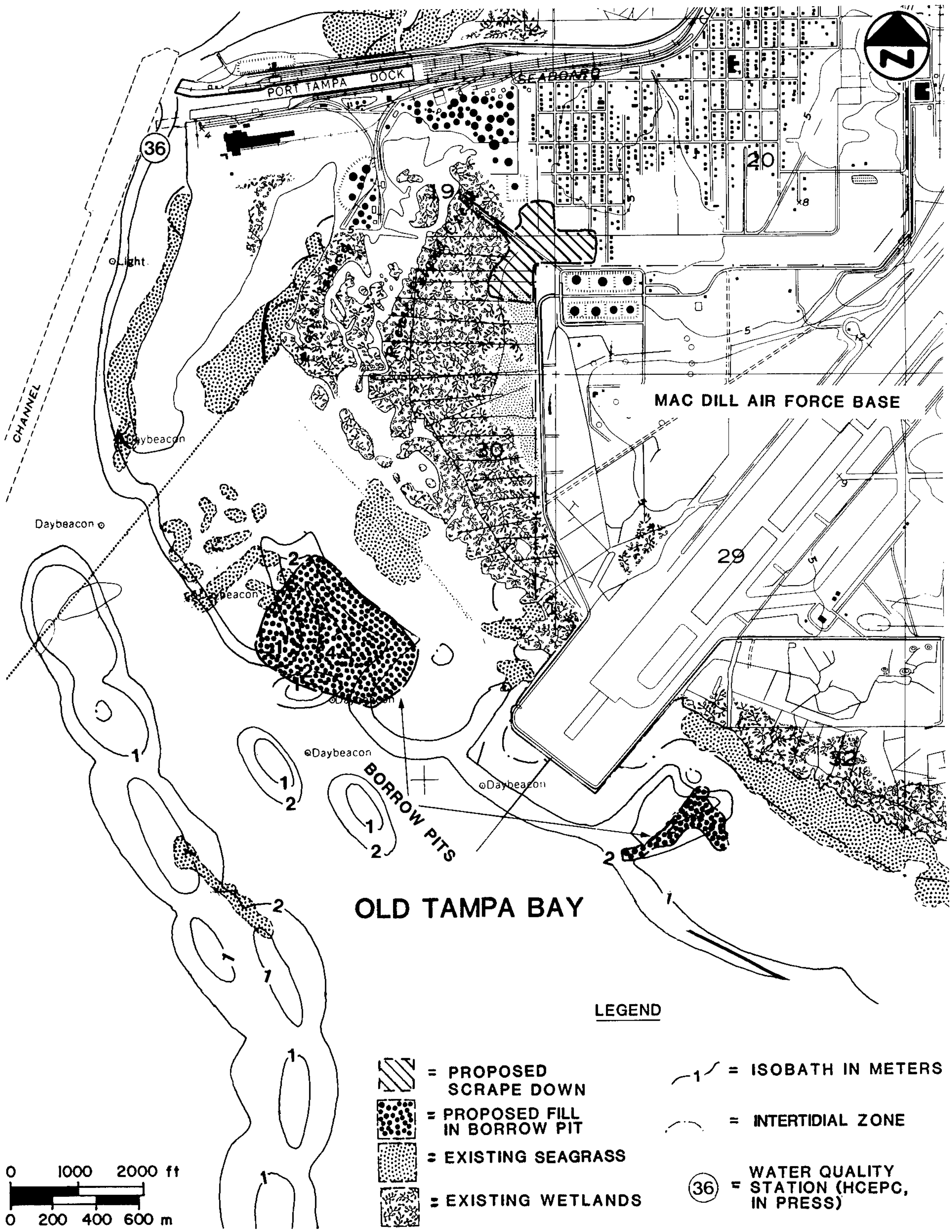


Figure 85. Map of the MacDill area mitigation sites (adapted from Kunneke and Palik 1984).

Table 32. Five-year (1978-83) average values for water quality parameters at stations in the vicinity of the MacDill area (from HCEPC, in press).

Water quality parameter	Annual average values: Station 13	Station 36
Total chlorophyll (µg/l)	28.3	31.7
Conductivity (µmhos)	39,281	40,399
Turbidity (NTU)	3.4	3.4
Temperature (°C)	22.9	22.8
Total nitrogen (mg/l)	0.75	0.66

raised to the photic zone by filling 39 ha of borrow pits with sand from a TPA project (Figure 85). A potential source of sand could be the emergency anchorage that has been proposed near Gadsden Point, providing this is approved. Filling the pits will provide a substrate suitable for colonization by submerged aquatic vegetation and in time provide habitat for fishes and invertebrates.

The disturbed upland site in its present condition is probably of little value as wildlife habitat. Increasing the area of wetlands marsh habitat should provide for enhancement and expansion of fishes and wildlife common to the adjacent wetlands. The marsh habitat could be created by scraping down the approximately 13 ha of upland habitat to intertidal elevations, planting with *Spartina alterniflora* or mangroves, and creating a fringing mangrove tidal creek in the area of the pipeline right-of-way (Figure 85).

Restoration of the existing wetlands along the west and south side of MacDill AFB should also be considered and further evaluated. Due to the network of mosquito ditches and spoil mounds in the area, tidal inundation of the high marshes and salt barrens appears inadequate.

3.2.2 Old Tampa Bay

a. Kaul fill site. Site Description: The Kaul fill site is located immediately north of the east end of the Gandy Causeway Bridge at the west end of Fairoaks Boulevard in Old Tampa Bay (Figures 69 and 86). This spoil area was created by dredging adjacent submerged lands. A dredge-and-fill application for dredging canals and site development is currently under review by the FDER. An enforcement action has also been initiated against the owner for unauthorized dredge-and-fill actions. The site currently consists of an upland spoil (Figures 87 and 88) with five small finger canals and a central lagoon receiving tidal inundation from Old Tampa Bay. A large borrow pit to the west of the fill and a smaller pit to the south are approximately 6 m in depth and devoid of submerged vegetation.

Water quality near the site is predominantly influenced by tidal action from Old Tampa Bay. Non-point source runoff into adjacent dead-end canals may also contribute to degradation in water quality near the site. The closest location for which long-term water quality is available is Station No. 50 as reported in HCEPC (in press). This station is located 2.4 km north of the Kaul fill site (Figure 86). Five-year annual values for water quality parameters collected at Station No. 50 are reported in Table 33.

Vegetation observed on the site during our field survey included grasses and upland exotic vegetation (Figure 88), a fringing marsh of *Spartina alterniflora* and *Distichilis spicata* in the interior lagoon, a series of narrow finger canals lined with black mangrove (*A. germinans*), and a small *S. alterniflora* marsh at the northeast end of the site. Seagrass beds were previously located at the site of the existing west borrow pit (CSA 1983). Dredging of this pit removed approximately 10 ha of seagrasses. Seagrass beds still are located west of the borrow pit (CSA 1983). All of the wetlands habitats receive tidal flushing from Old Tampa Bay and are thus considered jurisdictional wetlands.

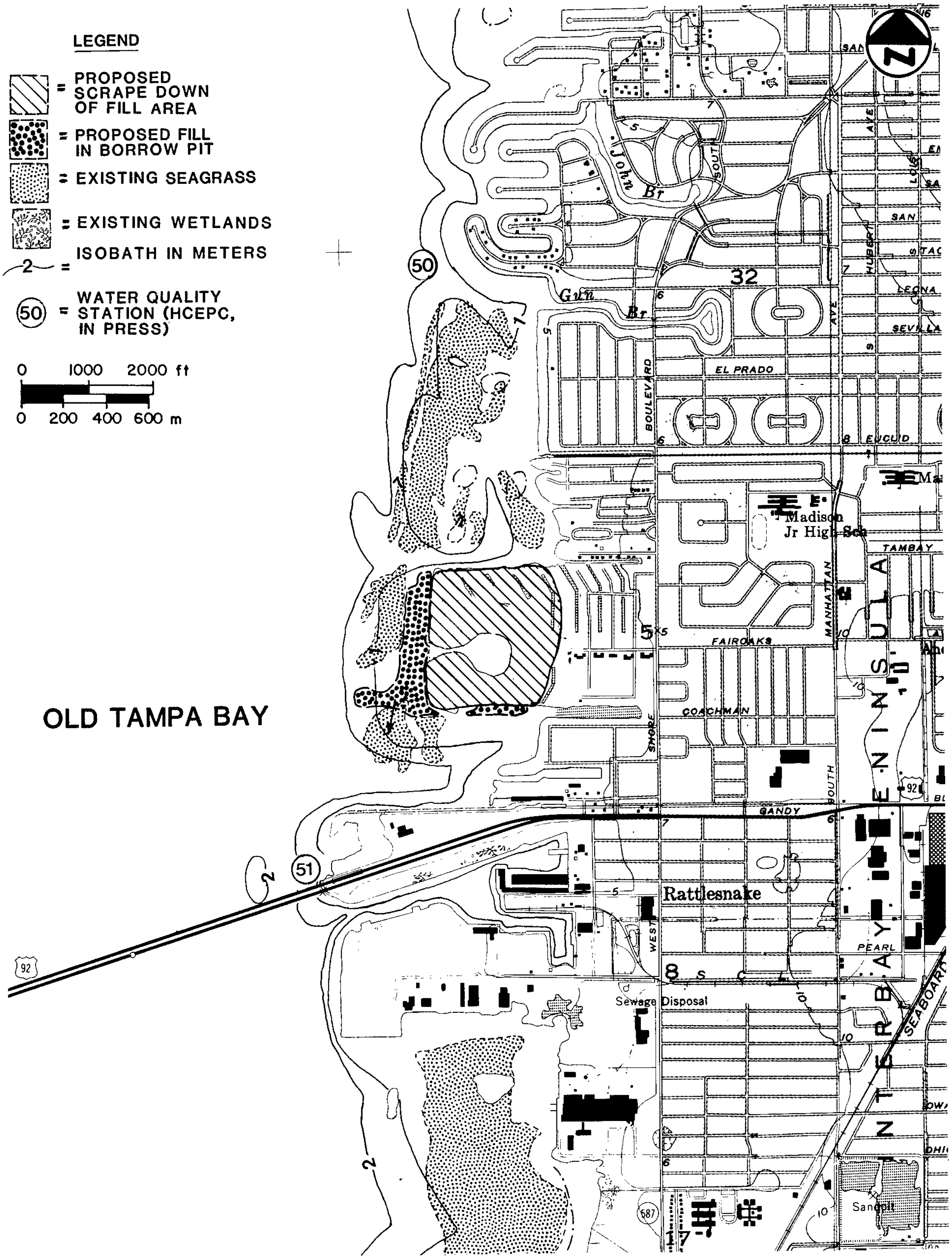


Figure 86. Map of the Kaul Fill mitigation site (adapted from Kunneke and Palik 1984).

Figure 87. View of south side of the Kaul fill site.

Figure 88. Upland grasses and interior lagoon located on the Kaul fill site.

Table 33. Five-year (1978-83) average values for water quality parameters at a station in the vicinity of the Kaul fill site (from HCEPC, in press).

Water quality parameter	Annual average values at Station 50
Total chlorophyll (µg/l)	23.6
Conductivity (µmhos)	39,314
Turbidity (NTU)	3.0
Temperature (°C)	23.2
Total nitrogen (mg/l)	0.69

Abundant fishes and wildlife were observed during our field survey. The interior lagoon appears to serve as a refugium from larger predatory fishes as access is limited due to a narrow and shallow inlet at the mouth of the lagoon. The dominant fishes observed included: Sheepshead minnow (Cyprinodon variegatus), killfishes (Fundulus spp.), bay anchovy (Anchoa mitchelli), striped mullet (Mugil cephalus), and redfin needlefish (Strongylura notata). The bay anchovy was particularly abundant. Ribbed mussel (Geukensia demissus), marsh periwinkle (Littorina angulifera), and queen conch (Melongena corona) were also common in the lagoon. Birds observed during the field survey included shorebirds [Least Tern (Sterna albifrons), Willet (Catoptrophorus semipalmatus), Herring Gull (Larus argentatus), Laughing Gull (Larus atricilla), Brown Pelican (Pelecanus occidentalis), American Oystercatcher (Haematopus palliatus), Clapper Rail (Rallus longirostris)] and wading birds [White Ibis (Eudocimus albus)]. Additional information on fishes and wildlife common to this portion of Old Tampa Bay is reported in Schomer et al. (in prep.) and Kunneke and Palik (1984).

Land use: This site is owned by Mr. Ralph Kaul who plans to build a residential waterfront community there. Surrounding land use includes navigational channels for recreational boat use and a residential development to the east of the site. The submerged lands are owned by the TPA. The FDER has jurisdiction over the wetlands in the canals and lagoon.

Mitigation plan: The goal is to create approximately 35 ha of marsh habitat and 10 ha of shallow subtidal bay bottom by scraping down uplands and filling in the adjacent borrow site to -4 ft MSL (Figure 86). To increase chances for success, public access can be limited by excavating a shallow north-south cut on the east side of the site. The interior lagoon could be preserved and enhanced by planting additional Spartina alterniflora sprigs. The subtidal fill area could eventually be colonized by neighboring seagrass beds. This site could also serve as a location for experimental seagrass planting. The site, following habitat creation and

enhancement, is envisioned to be an island surrounded by a *Spartina* marsh, with an interior lagoon and central high marsh for nesting shorebirds. It will be necessary to determine that erosion would not destroy the island. Small areas of native upland vegetation could also be planted for bird nesting.

b. Channel A. Site Description: Channel A is an artificial drainage canal located along the northeast side of Old Tampa Bay in Hillsborough County (Figures 69 and 89). The canal was constructed during the late 1960's for flood control (TBRPC 1985), and a salinity barrier was added in 1977-78 just north of Hillsborough Avenue (Dooris and Dooris 1984). The channel was dredged through extensive tidal wetlands to a depth of 2.1 m, and levees of spoil material were formed along the sides. The canal currently serves as a diversion for flood waters from Rocky Creek and as boat access to the bay for a residential development.

Construction of the channel levee has been blamed for disruption of tidal flushing patterns in the neighboring wetlands (TBRPC 1985). Freshwater outflow during the flood periods may also significantly alter the salinity patterns in the surrounding areas of Old Tampa Bay (TBRPC 1985). Water quality in Channel A and the surrounding area has been reported and/or collected by HCEPC (1983), Dooris and Dooris (1984), FDER (1984), and Kunneke and Palik (1984). Water quality (i.e., turbidity, BODs, total phosphorus, pH, dissolved oxygen, and color) is poorer in Channel A than in the lower reaches of Rocky Creek. Only total nitrogen concentrations and bacterial counts are higher in Rocky Creek than in Channel A. In comparison with Rocky Creek, Channel A has a two-fold greater chlorophyll *a* concentration, lower nitrate levels, and a similar nitrogen concentration (HCEPC 1983; Dooris and Dooris 1984). Proposed expansion of the River Oaks municipal AWT plant, which presently discharges 4.84 mgd into Channel A to 12 mgd, has not been recommended by the FDER (1984). The results of their wasteload allocation study for the Tampa Bay region state that additional discharges into Channel A would further degrade the water quality of Old Tampa Bay. For a period from September 1978 to August 1983, ambient water quality data were collected from Station No. 47 located off the Courtney Campbell Causeway (Figure 89). These five-year averages are reported in Table 34.

Vegetation present at this site includes disturbed upland vegetation, marsh grasses, and submerged seagrass beds. Extensive tidal wetlands dominated by *Spartina alterniflora* and *Avicennia germinans* are located north and south of the channel (Figure 90). A sparse band of *S. alterniflora* and small *A. germinans* fringe the interior banks of the canal (Figure 91). High marsh areas are characterized by the presence of *Distichlis spicata*, *Batis maritima*, and *Salicornia virginica*. Submerged vegetation, including *Ruppia maritima* and drift algae, occurs in sparse beds along this shore of Old Tampa Bay (CSA 1983).

Fishes and wildlife observed during our survey were found to be quite abundant in the tidal marshes north of the canal spoil bank. Numerous wading birds [Great Blue Heron (*Ardea herodias*), Green Heron (*Butorides striatus*), White Ibis (*Eudocimus albus*)], diving birds [Double-crested Cormorant (*Phalacrocorax auritus*)], and shorebirds [Willet (*Catoptrophorus semipalmatus*)] were observed foraging in the tidal marshes. Fishes collected included longnose killifish (*Fundulus similis*), sheepshead minnow (*Cyprinodon variegatus*), and bay anchovy (*Anchoa mitchelli*). Additional fishes common to Old Tampa Bay are listed in Comp (1984) and Layne et al. (1977).

Land use: Adjacent submerged lands are under ownership and jurisdiction of the TPA. The upland canal easement and upland spoil levees extending into the bay are under ownership of the Southwest Florida Water Management District.

Mitigation plan: Issue No. 34 in *The Future of Tampa Bay* (TBRPC 1985) is the development of a restoration plan for Channel A. Adverse impacts which have occurred from channel construction have been recognized by the Pinellas/Anclote Basin Board (TBRPC 1984), which has recommended appropriation of funds for wetlands restoration. The TBRPC (1984) has developed several recommendations,

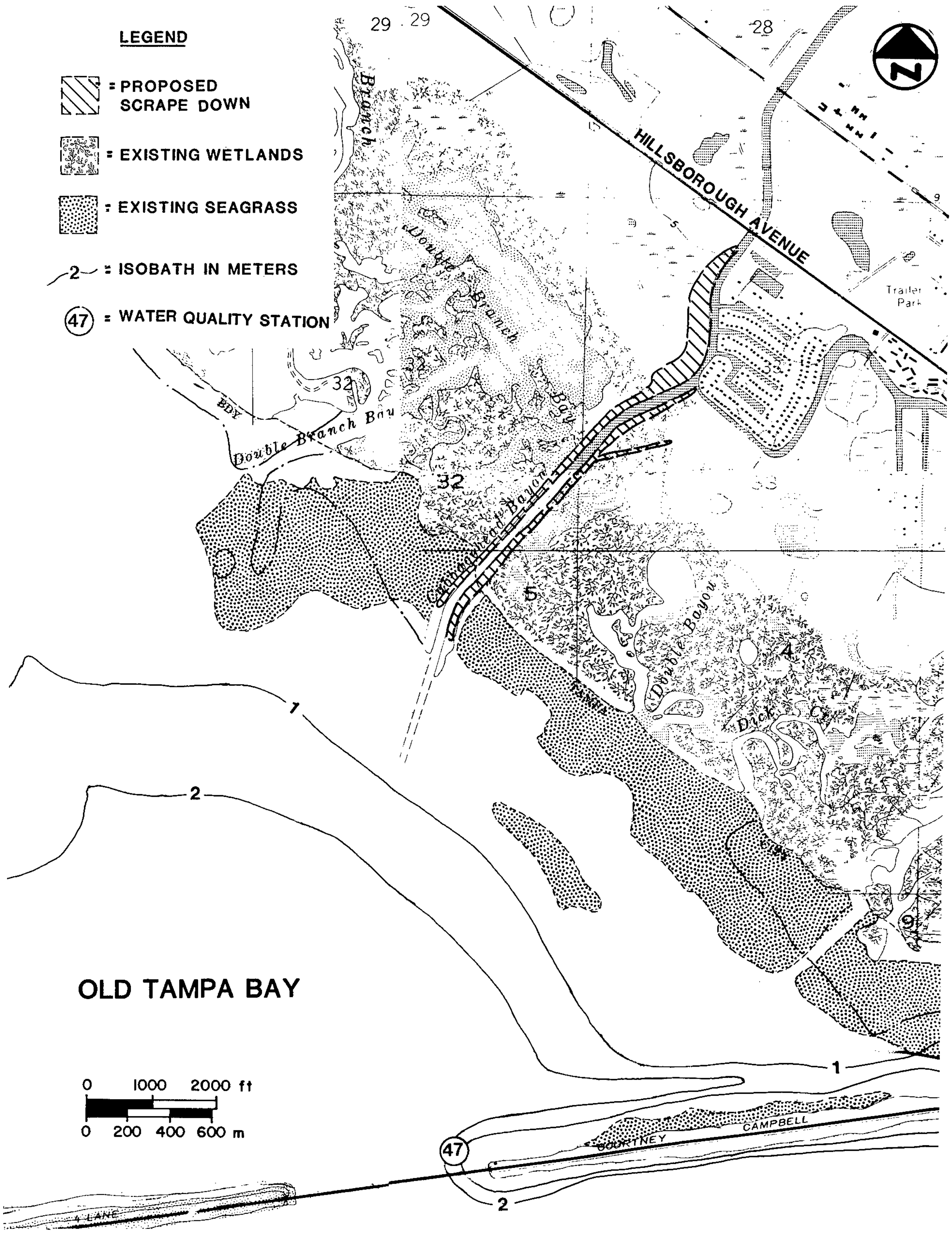


Figure 89. Map of the Channel A mitigation site (adapted from Kunneke and Palik 1984).

Five-year (1978-83) average values for water quality parameters at a station in the vicinity of Channel A (from HCEPC, in press).

Water quality parameter	Annual average values at Station 47
Total chlorophyll (μg/l)	27.4
Conductivity (μmhos)	38,488
Turbidity (NTU)	4.4
Temperature (°C)	22.4
Total nitrogen (mg/l)	0.81

Figure 90. Channel A spoil berm, fringing marsh, and adjacent wetlands to the north.

including habitat creation, filling of Channel A, water quality improvements, and restoring tidal flushing.

Approximately 19 ha of tidal marsh could be created by the removal or scraping down of spoil levees (Figure 92) and planting of Spartina alterniflora sprigs (Figure 89). The depth and width of the channel could also be reduced. Spartina alterniflora sprigs could then be planted in replacement of the levees. This area appears to be highly utilized by wading birds and resident fish species. The creation of more wetlands could serve to enhance habitat for fishes and wildlife.

c. Booth Point. Site Description: Booth Point is a peninsula separating Safety Harbor from Mobbly Bay in northern Pinellas County (Figures 69 and 93). The site selected for this study comprises the uplands and tidally ditched wetlands located along the southeastern end of the peninsula (Figures 93 and 94), specifically those located east of the transmission line corridor from Higgins Power Plant.

Mobbly Bay receives freshwater input from Mobbly Bayou and tidal exchange from the waters of Old Tampa Bay. The steam generated electric plant at Higgins Point also releases thermal effluent into lower Mobbly Bay. Tidal flushing is poor, with a net tidal current of 3.4 to 60 cm/s. Hillsborough County Environmental Protection Commission (in press) more

Figure 91. Fringing marsh and upland berm along north side of Channel A.

Figure 92. Typical view of spoil banks proposed for excavation in Channel A.

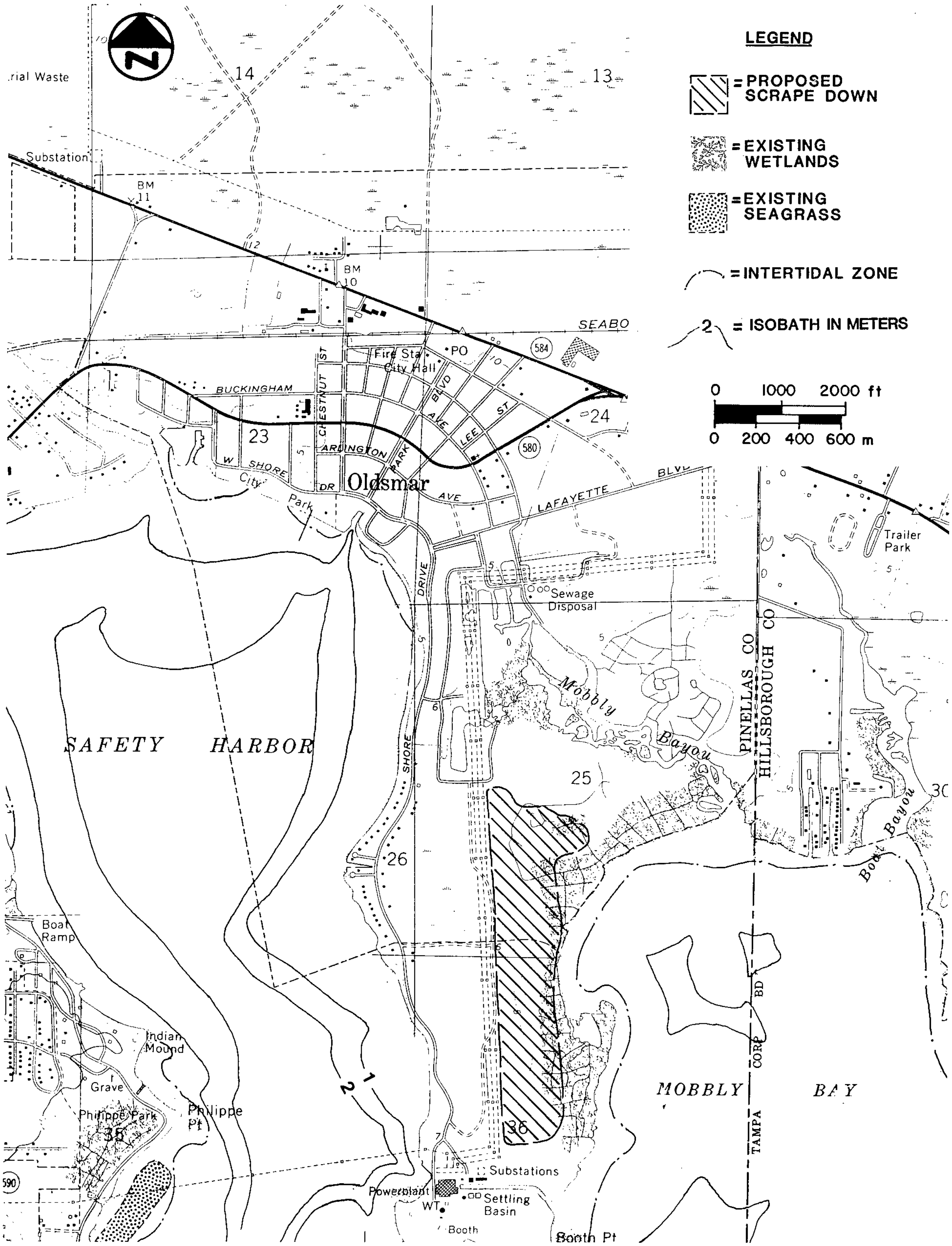


Figure 93. Map of the Booth Point mitigation site (adapted from Kunneke and Palik 1984).

Figure 94. View of Mobbly Bay (background), wetlands, and uplands northeast of Florida Power Corporation's Higgins Plant. Proposed mitigation site includes upland and wetlands on the far side of the transmission corridor.

recently found that particles dispersed in northern Old Tampa Bay may take up to 20 mo to flush (Kunneke and Palik 1984).

The water quality of Mobbly Bay has not been thoroughly investigated. Data have been reported and averaged for a period from September 1978 to August 1983 by the HCEPC for a Station (No. 46) located south of Booth Point (Kunneke and Palik 1984). Five-year average values for the measured water quality parameters are reported in Table 35. The FDER evaluated the potential for new discharges into Mobbly Bay. Model simulations showed that consistently poor water quality would result from a new outfall or increased discharges. The FDER projected that increased discharges would cause a 5 ug/l increase in chlorophyll *a* concentration during high flow and 10 ug/l during low flow.

Table 35. Five-year (1978-83) average values for water quality parameters at a station in the vicinity of Booth Point (from HCEPC, in press).

Water quality parameter	Annual average values at Station 46
Total chlorophyll (μg/l)	25.5
Conductivity (μmhos)	35,477
Turbidity (NTU)	5.8
Temperature (°C)	22.6
Total nitrogen (mg/l)	0.87

Vegetational habitats observed during our site survey include pine flatwood, pine oak-scrub, high marsh fringe, and tidally inundated fringing low marshes (Figures 95, 96, 97). Dominant high marsh vegetation includes *Distichlis spicata*, *Batis maritima*, and *Salicornia virginica*. Fringing marshes along the spoil bands are characterized by *Spartina alterniflora*, *Avicennia germinans*, and *Laguncularia racemosa*. The *Spartina* marsh and mangrove habitat located immediately along Mobbly Bay are lower in elevation than the tidal marshes farther inland. Upland spoil banks and levees created by the tidal creek ditching are vegetated by high marsh (*Distichlis spicata*, *Batis maritima*) and upland vegetation (*Schinus terebinthifolius*, *Baccharis haliminifolia*). Mangroves along the tidal creeks were stunted in size and showed considerable freeze damage. *Juncus*

Figure 95. Interior tidal creeks at Booth Point showing freeze damaged mangroves, *Juncus roemerianus*, *Salicornia virginica*, and upland vegetation on spoil mounds.

Freeze damaged mangrove habitat at Booth Point site.

Figure 97. Drainage creek and pine flatwoods looking west from the Booth Point site.

roemerianus also grows at the north end of the site in a transitional habitat between the tidally ditched wetlands and pine flatwoods. Some of the tidal ditching appears to have occurred through upland habitat, as some mature cabbage palms and scrub oak vegetation are present on several spoil mounds.

Fishes and wildlife observed during our study include wading birds [Great Blue Heron (Ardea herodias), White Ibis (Eudocimus albus)], forest arboreal birds [Blue Jay (Cyanocitta cristata), Mockingbird (Mimus polyglottos)], fishes [sailfin molly (Poecilia latipinna), sheepshead minnow (Cyprinodon variegatus)], and invertebrates [fiddler crabs (Uca spp.), Florida crown conch (Melongena corona)]. Additional birds common to Old Tampa Bay are listed in Schomer et al. (in prep.). Fishes common to Old Tampa Bay are reported in Comp (1984) and Layne et al. (1977).

Land use: The tidal wetlands and adjoining uplands are owned by the Florida Power Corporation (FPC) (David Voigts, FPC; pers. comm., 1985). The Higgins Point electric plant and transmission corridor occupy most of their land. Adjacent land includes residential areas, State submerged lands, and land owned by the City of Oldsmar's sewage treatment plant located north of the FPC site. Access to the area is limited and bounded by the transmission lines to the west of the site, FPC to the south, and the Oldsmar sewage treatment plant to the north.

Mitigation plan: Tidally ditched uplands, wetlands, and spoil levees currently do not provide much open marsh habitat for fishes and wildlife. Disturbed upland areas and the stunted or stressed fringe of mangroves and Spartina alterniflora do not appear to be highly productive areas. Habitat creation on the site could be accomplished by selectively scraping down or excavating the spoil mounds and levees adjoining the ditched tidal creeks. Approximately 9 ha of land could be scraped down to intertidal elevations suitable for planting S. alterniflora (Figure 93). In addition, 40 ha of adjacent upland habitat could be excavated and planted to create a high marsh zone between the low marsh and pine flatwoods. The newly created intertidal land could be planted with S. alterniflora and the high marsh with Distichlis spicata and Salicornia virginica. Following the development of a mature Spartina marsh, mangrove recruitment could be encouraged by providing seed propagules if the mangroves have not naturally recruited.

d. St. Petersburg-Clearwater International Airport. Site Description: The St. Petersburg-Clearwater International Airport site is located on the western shore of Old Tampa Bay in Pinellas County (Figures 69 and 98). Specific areas for habitat creation include the shoreline northwest of the end of the north-south runway, the upland and intertidal fringe along the northeastern shoreline, and two previously dredged borrow pits east of the north-south runway.

The waters of Old Tampa Bay in the vicinity of the airport receive freshwater input via the Cross Bayou Canal. The canal receives 15 million gallons per day from the City of Largo municipal sewage treatment plant as well as inputs from other industrial dischargers (Schomer et al. in prep.). Net tidal currents west of the airport extension are from the northwest and average 0.03 to 3.0 cm/s. Net tidal currents on the east side are from the north-northeast and at the 2-m contour move southeast along the shoreline.

Water quality for the airport and surrounding area has been reported and averaged for a period from September 1978 to August 1983 by the HCEPC (Station No. 65). This station is located approximately 1.0 km due north of the end of the airport extension (Figure 98). Five-year average annual values for the measured water quality parameters are reported in Table 36. Additional data for the Cross Bayou Canal have been collected by the FDER and are available through the STORET data base.

The vegetational habitats observed during our field survey include fringing patches of *Spartina alterniflora* and *Laguncularia racemosa* west of the runway terminus, and a band of mature *Rhizophora mangle* and *L. racemosa* at the entrance to the canal. The runway approach is non-vegetated and either bulkheaded or riprapped. The east end of the airport property is sparsely vegetated with unhealthy *L. racemosa*, *Baccharis halimifolia*, *Casuarina equisetifolia*, and *Schinus terebinthifolius*. A sand/shell beach grades into a silty-sand substrate offshore. Sparse *Ruppia maritima* and drift algae occur in the subtidal areas west and east of the airport extension (CSA 1983).

Table 36. Five-year (1978-83) average values for water quality parameters at stations in the vicinity of the St. Petersburg-Clearwater Inationational Airport (from HCEPC, in press).

Water quality parameter	Annual average values at Station 65
Total chlorophyll (μg/l)	32.7
Conductivity (μmhos)	35,609
Turbidity (NTU)	6.3
Temperature (°C)	22.5
Total nitrogen (mg/l)	1.00

The only wildlife observed during our field survey were wading birds [Great Blue Heron (*Ardea herodias*), Little Blue Heron (*Florida caerulea*), and White Ibis (*Eudocimus albus*)]. Additional birds common to Old Tampa Bay are reported in Schomer et al. (in prep.). Fishes occurring in Old Tampa Bay and tidal creeks are listed in Comp (1984) and Schomer et al. (in prep.). Fishes that would be expected to occur in this area include killifishes (Cyprinodontidae), mojarras (Gerreidae), anchovies (Engraulidae), drums (Sciaenidae), snook (Centropomidae), snappers (Lutjanidae), sea catfishes (Ariidae), gobies (Gobiidae), mullet (Mugilidae), stingrays (Dasyatidae), and jacks (Carangidae) (Schomer et al. in prep.).

Land use: The upland portion of this site is presently owned by Pinellas County. The submerged lands are owned by the State of Florida. The waters are designated as Class II Outstanding Florida waters. Adjacent land use includes undeveloped property east of the airport, and residential and commercial land west of the airport and canal.

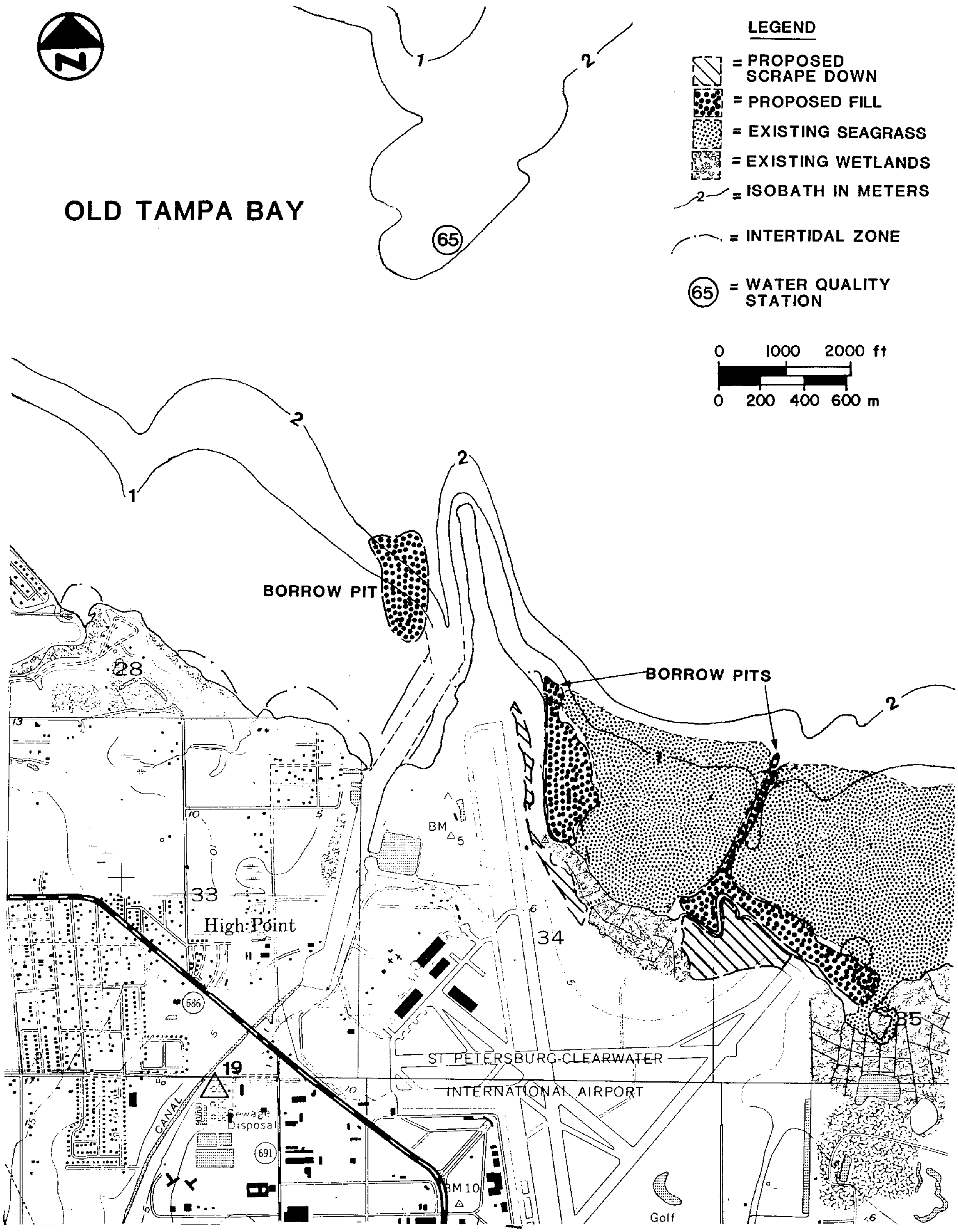


Figure 98. Map of the St. Petersburg-Clearwater Airport mitigation site (adapted from Kunneke and Palik 1984).

Mitigation plan: The mitigation goal is to provide additional wetlands habitat for fish and wildlife usage. A project in this area is likely to be successful because the airport site is not accessible to the general public. The creation of *Spartina* marsh, intertidal mud flats, or shallow subtidal habitat conducive to seagrass colonization totalling 45 ha could be accomplished at three locations (Figure 98). The mitigation plan for each of these areas is as follows:

1) Create 8 ha of marsh habitat along the west side of the runway terminus by pumping spoil material along the shoreline; stabilize the fill material, and plant with *S. alterniflora* sprigs. Spoil material could be obtained through upland sources, port dredging, or from dredging a shoal located west of the channel.

2) Create 10 ha of shallow subtidal habitat suitable for seagrass colonization by filling in a dredged borrow pit (2.4 to 3.0 m deep) located east of the north end of the runway. Fill material could be scraped from adjacent upland, pumped in from a barge or brought in from an offsite sand source. Also 4 ha of marsh habitat could be created by scraping down upland.

3) Create 6 ha of marsh habitat northeast of the east end of the east-west runway by scraping down sparsely vegetated upland and also 17 ha of subtidal habitat by filling an existing borrow pit. The excavated upland and filled borrow pit could then be planted with *S. alterniflora* sprigs.

e. West End Howard-Frankland Causeway. Site Description: During construction of the west causeway of the Howard-Frankland Bridge in 1958, fill material was obtained by dredging sand from Tampa Bay (Figure 69). This dredge-and-fill operation resulted in the creation of a large borrow pit along each side of the causeway (Figure 99). Depths in these pits range from 3.7 to 4.9 m and the substrate is composed of silty-sand and mud. These dredged pits currently serve as harbor areas for a few local recreational and commercial fishermen. *Ruppia maritima* and drift algae are quite abundant in the Feather Sound area north of the causeway. Sparse patches of *R. maritima* are present in the photic zone south of the causeway along the shoreline and beyond the borrow pit (CSA 1983; Lewis et al. 1984).

Water quality data have been collected and reported for the period from September 1978 to August 1983 by the HCEPC. Stations No. 66 and 46 are the closest stations to the site (Kunneke and Palik 1984). Five-year average annual values for these water quality parameters are reported in Table 37. Water quality, especially dissolved oxygen levels, could be lower in the borrow pits than at the stations sampled. Because these pits are well below the photic zone, seagrass would not be expected to occur. The benthic community would also be expected to be less diverse in the borrow pit than in the surrounding shallower subtidal flats. Fish and wildlife usage within the borrow pits has not been documented. Fish utilization of the seagrass flats in the Big Island area prior to construction of the causeway was documented by Springer and Woodburn (1960). They documented the

Table 37. Five-year (1978-83) average values for water quality parameters at stations in the vicinity of the Howard-Frankland Causeway (from HCEPC, in press).

Water quality parameter	Annual average values: Station 46	Station 66
Total chlorophyll (μg/l)	25.5	27.4
Conductivity (μmhos)	35,477	36,508
Turbidity (NTU)	5.8	5.2
Temperature (°C)	22.6	22.5
Total nitrogen (mg/l)	0.87	0.82

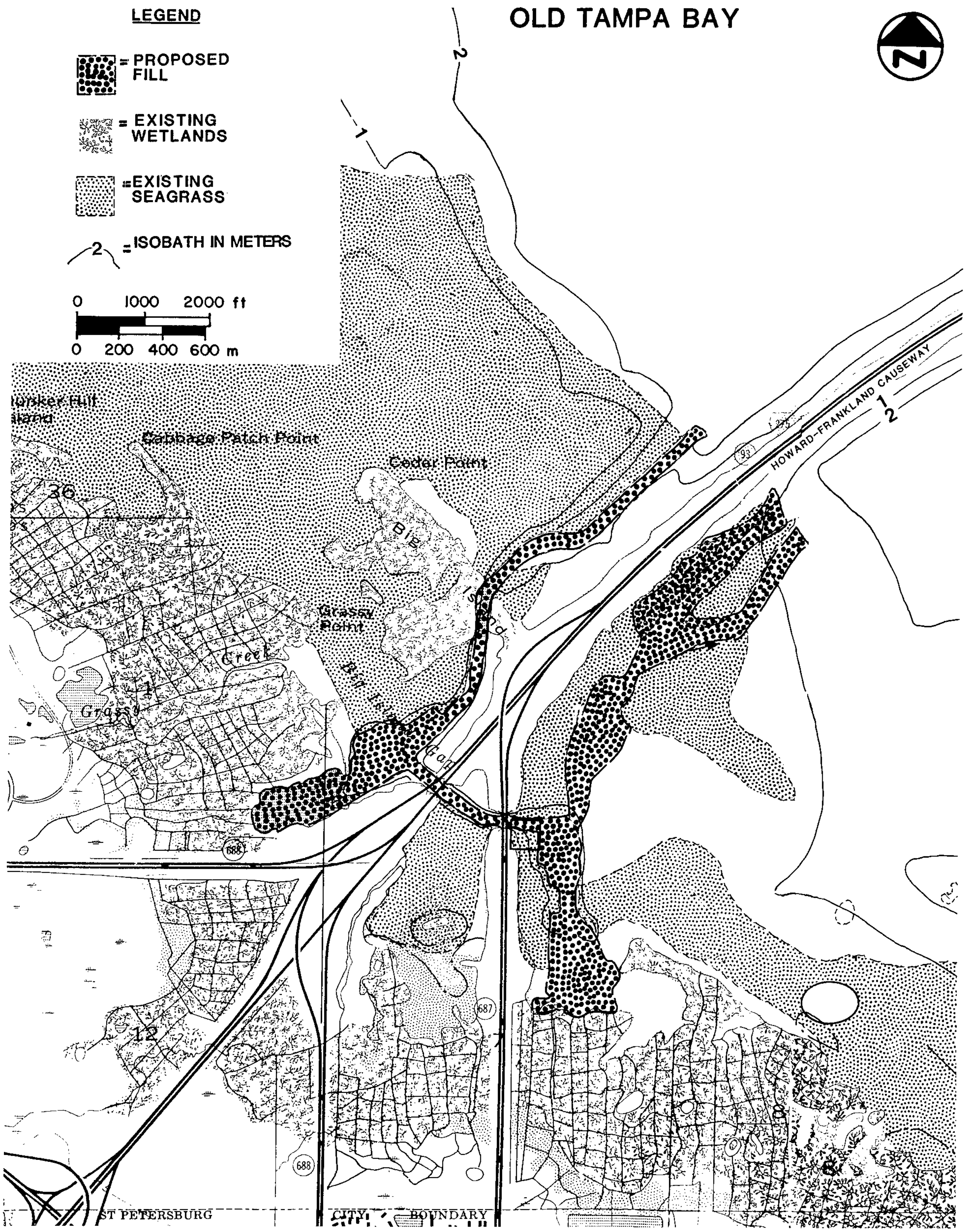


Figure 99. Map of the west end of the Howard-Frankland Causeway mitigation site (adapted from Kunneke and Palik 1984).

occurrence of 57 species in this region of Old Tampa Bay. More recent work by Comp (1984) as reported in Schomer et al. (in prep.) provides a listing of the estuarine bay fringing fish community typically associated with these adjacent shallow tidal flats.

Land use: The submerged land is owned by the State of Florida. The waters are classified as Class II waters. The Howard-Frankland Bridge and Causeway is also under State ownership and jurisdiction by the FDOT.

Mitigation plan: The objective of this mitigation plan is to raise the elevation of two large borrow pits to the photic zone (-1.1 to 1.2 m MSL) (Figure 99). This will provide a good substrate and depth for the establishment of benthic algae and seagrasses and in time provide more shallow subtidal habitat for fishes and wildlife common to the adjacent areas (Comp 1984). A total of approximately 95 ha of shallow subtidal habitat could be created. Care would have to be taken not to destroy the adjacent seagrass beds during the restoration. It is recommended that good quality construction grade spoil be used to fill the pits. Use of maintenance dredge material could be considered for the lower half if the pits were capped with construction material. As evidenced at Lassing Park (Chapter 1.0), subsidence of fine materials may necessitate an initial overfilling of the pits. Attempts should be made to utilize fill similar in grain size to sediments found in the adjacent *Ruppia maritima* beds.

3.2.3 Lower Tampa Bay

a. Perico Bayou. Site Description: The Perico Bayou site is located in the western part of the City of Bradenton in Manatee County (Figures 69 and 100). A levee currently surrounds a large area of mangrove habitat which receives tidal flushing through a small creek at the northeast end of the site (Figure 101). A series of one-way culverts under the levee allow excess water to flush out of the impounded mangrove area. To the south of the impoundment levees is a salt barren area (Figures 100 and 102). This levee was constructed to prevent flooding of preexisting crop lands (Patton and Associates, Inc. 1985). The lack of tidal access to this salt pan has severely reduced the viability of plants occurring there. Much of the salt pan has dried up and is presently being invaded by upland grasses. This may also be true for some of the interior mangrove habitat within the impoundment.

A tidal flushing and modeling study including the impoundment and tidal inlet indicates this area has a low flushing exchange in its present state, as is evidenced by the stressed mangroves (Patton and Associates, Inc. 1985). The modelers recommended that the tidal inlet at the northeast end be widened from 9 to 30 m to decrease the stagnant waters in the mangrove preserve. Removal of the levees has not been evaluated as an alternative. Modeling results indicated that increasing the size of the culverts would not significantly improve flushing. Water quality data for the impoundment are not available. Water entering the tidal creek at the northeast end is predominantly influenced by water quality in the Manatee River and Tampa Bay (Figure 100). Five-year average annual values for water quality parameters measured from September 1978 to August 1983 at Station No. 92 are shown in Table 38 (HCEPC, in press). Station No. 92 is located approximately 3.2 km north of the site in 4 m of water (Kunneke and Palik 1984). Lack of proper flushing within the impoundment could contribute to reduced dissolved oxygen concentrations.

Site vegetation as observed during our survey includes a mature mangrove swamp (*Rhizophora mangle*, *Laguncularia racemosa*, *Avicennia germinans*, *Conocarpus erecta*) bordering the west and north levees and interior fringe adjacent to the levees; expansive offshore seagrass beds and tidal flats (CSA 1983; Lewis et al. 1984, Figure 103); a salt marsh or salt pan community (*Distichlis spicata*, *Salicornia bigelovii*, *S. virginica*, *Batis maritima*, *Sesuvium portulacastrum*, *Solidago sempervirens*, *Borrichia frutescens*, and *Iva frutescens*); and an upland plant community dominated by *Schinus terebinthifolius*, *Casuarina equisetifolia*, and *Andropogon* spp.

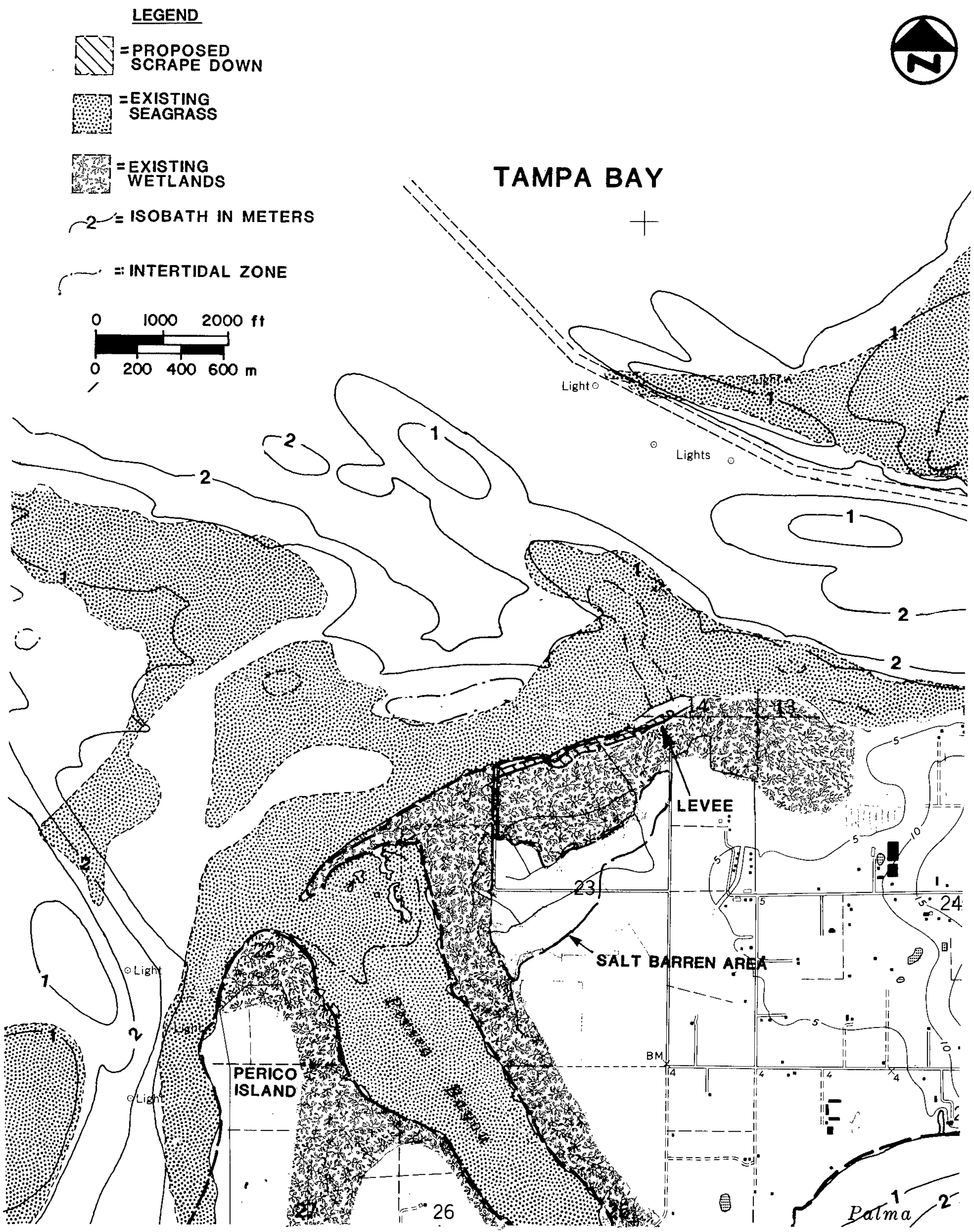


Figure 100. Map of the Perico Bayou mitigation site (adapted from Kunneke and Palik 1984).

Table 38. Five-year (1978-83) average values for water quality parameters at a station in the vicinity of the Perico Bayou (from HCEPC, in press).

Water quality parameter	Annual average values at Station 92
Total chlorophyll (µg/l)	15.6
Conductivity (µmhos)	52,240
Turbidity (NTU)	4.3
Temperature (°C)	23.3
Total nitrogen (mg/l)	0.46

Figure 101. Mangrove lined tidal creek entering the mangrove swamp at the northeast side of the Perico Bayou site.

Figure 102. Salt barrens (foreground) and vegetated spoil berm (background) on the Perico Bayou site.

Figure 103. Mangrove fringe and tidal flats north of the Perico Bayou site.

Fish and wildlife usage of this area of Tampa Bay is very high (Schomer et al. in prep.) due to the expanse of wetlands habitat available. The tidal flats present in Perico Bayou and off the north end of the site support productive clam beds and are designated by the State of Florida as approved shellfish harvest areas (Kunneke and Palik 1984). Comp (1984) provides a summary of the distribution and occurrence of fishes in the Tampa Bay area, as well as a discussion of the relationships between wetlands habitat and fishery resources. Fishes observed in the impounded mangroves inlet include permanent residents [killifish (Fundulus sp.), sheepshead minnow (Cyprinodon variegatus), sailfin molly (Poecilia latipinna), mosquitofish (Gambusia affinis)] with high tolerances to low oxygen concentrations. Fishes common to the offshore tidal flats and

seagrass beds are reported in Comp (1984) and Schomer et al. (in prep.). Birds commonly associated with mangrove habitats and tidal flats are described in Schomer et al. (in prep). A number of White Ibis (Eudocimus albus) and Little Blue Heron (Florida caerulea) were observed along the north shoreline near the tidal inlet.

Land use: Most of the upland areas at this site are currently owned by the Wilbur Boyd Corporation (River Bay, Inc.) and are included in plans for a golf and waterfront residential development. Wetland habitat north and west of the site is State-owned and under jurisdiction of the FDER. The property east of the site is agricultural and low density residential land. The interior mangrove habitat is under FDER jurisdiction.

Mitigation plan: The mitigation goal is to improve tidal connections with the impounded mangrove swamp and salt barrens. This will serve to enhance and expand habitats for fish and wildlife.

A total of approximately 31 ha of mangrove and salt barrens could be improved through site acquisition and 2.5 ha could be created through excavation of the levees to adjacent wetland elevations (Figure 100). Recruitment onto the excavated upland by mangroves will occur naturally in a short period of time. Restoring tidal flushing to the salt barrens may also result in natural recruitment of native high marsh vegetation. A maintenance program to remove and control competitive exclusion by disturbance vegetation could be implemented. Although removal of the levees should restore natural flushing between the impounded mangrove habitat and adjacent wetlands, additional tidal creeks or ditches may be needed.

3.3 SUMMARY AND RECOMMENDATIONS

Twelve potential mitigation sites were evaluated: six in Hillsborough Bay, five in Old Tampa Bay, and one in Lower Tampa Bay. The proposed mitigation plans for the Hillsborough Bay sites would involve filling 47 ha of old dredged borrow pits, filling 165 ha of subtidal sand flats for creation of mangrove or marsh habitat, and scraping down 52.2 ha of disturbed upland and transitional wetlands habitat for marsh creation. The proposed mitigation plans for the Old Tampa Bay sites would involve filling 132 ha of dredged borrow pits and scraping down 121 ha of disturbed upland. At the Lower Tampa Bay site, the plan calls for scraping down of 2.5 ha of disturbed upland for marsh creation. After evaluating the value of existing benthic habitats, filling subtidal areas may not be acceptable as mitigation. Additional projects for Manatee County are being developed by the FDNR (Evans 1985).

At a majority of the sites evaluated or selected as suitable for habitat creation, submerged lands are owned by the TPA or other State or local public agencies (e.g., SWFWMD). Of the 12 sites proposed, 11 are located all or in part on submerged lands owned by the TPA or other governmental entities. Three sites encompass some privately owned land.

Prioritization of the sites should be based on data concerning wetland habitat loss (i.e., Tampa Bay Trend Analysis Study) for each area of the bay and/or needs for particular habitats or species. The wetland trend study has not been completed and identification of needs for particular habitats or species has not as yet been attempted. Criteria that could be used to assign site priority in the absence of information on habitat loss and needs include: (1) land ownership (use of public owned lands will minimize costs); (2) needs for and feasibility of restoration in relation to future port-related projects; and (3) relationships to bay-wide restoration efforts and habitat needs. Site selection should also involve consideration of anticipated TPA needs in terms of expansion, improvement, or maintenance, and the types and amounts of unavoidable habitat losses projected. If the goal is to mitigate unavoidable losses due to future port development, a balance between habitat needs and anticipated unavoidable losses should be established.

Additional important factors to be considered in relation to site selection include pumping distances, suitability of dredged material for habitat creation, and the quantity of dredged material needed.

Only sites within Hillsborough County may prove feasible from an engineering viewpoint; sites in Old Tampa Bay, excluding MacDill, would probably exceed maximum allowable pumping distances. Projections of the volume of material to be dredged over the next 25 years are currently being compiled by the TPA. Of the total volume, most will be maintenance dredged material that may not be suitable for habitat creation. The potential use of maintenance dredged material for habitat creation should be evaluated further or disposal on upland or offshore sites may be necessary.

The feasibility of alternate sand sources for some of the projects should be considered. Future TPA dredging and development activities may not generate enough good quality fill material required to complete the selected mitigation projects. Upland sand sources for some of the projects may need to be considered, especially those in upper Old Tampa Bay which are isolated from TPA projects.

Another problem to be concerned with is the scarcity of single large upland sites for habitat creation. Proposed projects at 9 of the 12 sites evaluated involve the scraping down of uplands. The size of the proposed sites ranges from 2 ha (Delaney pop-off canal) to 49 ha (Booth Point). Of the proposed areas for habitat creation involving the scraping down of uplands, 30% and 69% by area are located in Hillsborough Bay and Old Tampa Bay, respectively. In light of this scarcity of upland habitat for creation of new wetlands, restoration and enhancement of existing degraded wetland may need to be evaluated though this type of mitigation will not be acceptable for loss of wetland habitat. Mitigation needs for development may require that avoidance, reduction, and minimization of adverse effects be pursued as mitigation rather than destruction of wetland habitat.

Finally, it is important to note that some of the sites included in this chapter have previously been considered for mitigation projects. Some proposed projects were not implemented because of local public opposition or political problems. Similar difficulties are likely to be encountered in implementing some of the projects proposed here.

CHAPTER 4. RELATIONSHIP OF MITIGATION TO ENVIRONMENTAL MANAGEMENT IN TAMPA BAY

4.1 TECHNICAL APPROACH

The goal of Chapter 4 is to define the relationship of mitigation to environmental management in Tampa Bay. This goal is accomplished by defining:

1) the current authorities that manage resources in Tampa Bay;
2) mitigation and the mitigation alternatives available;
3) the current status of mitigation in Tampa Bay; and
4) recommendations for approaches to mitigation.

Information was gathered through the means identified in previous chapters.

4.2 CURRENT MANAGEMENT OF RESOURCES IN TAMPA BAY

Many Federal, State, and local government agencies have legislatively mandated authority to regulate or manage resources within Tampa Bay. Conflicting authorities and overlapping jurisdictions have produced a lack of consistent management within specific areas of the bay [Tampa Bay Regional Planning Council (TBRPC) 1983]. The existing authorities within Tampa Bay according to activity (resource utilization, management, and/or development) and category of agency involvement (regulation/enforcement, review/advisory, planning/policy, or research/education) are listed in this document. The following summarizes the roles of various agencies in permitting activities, particularly port-related activities, within Tampa Bay.

4.2.1 Federal Involvement

The USACE has a broad range of regulatory and permitting authority within jurisdictional waters. Jurisdiction and regulatory functions are based on Section 10 of the River and Harbor Act of 1899 and Section 404 of the Clean Water Act of 1977 (see Chapter 1, Section 1.3.9 for more information). During the permitting process, the USACE solicits recommendations on the permissibility of the project from the USFWS, the National Marine Fisheries Service (NMFS), and the Environmental Protection Agency (EPA). The USFWS reviews and provides recommendations on the impact of projects on fish and wildlife habitat under the Fish and Wildlife Coordination Act (FWCA), Endangered Species Act, and the Marine Mammal Protection Act (Section 4.3 expands upon the relationship). The NMFS, under the Magnuson Fisheries Conservation and Management Act and FWCA, is responsible for habitat protection and fisheries management for estuarine and marine fishes. The NMFS advises the USACE concerning the impact of projects on fish and wildlife habitat under these acts and provisions of the Endangered Species Act and the Marine Mammal Protection Act. The EPA has the responsibility of establishing and enforcing national water pollution control standards through the Clean Water Act and the National Pollutant Discharge Elimination System. The USACE is the permitting agency. The EPA comments to the USACE on the permissibility of projects and can veto permits under the authority granted in Section 404(c) of the Clear Water Act.

The U.S. Coast Guard has a broad range of regulatory and enforcement powers involving navigation, including anchorages, bridge construction and some piers, and oil pollution from onshore and offshore facilities and vessels. It does not, however, comment on the environmental aspects of coastal construction under

USACE permit authority unless navigation is involved.

The U.S. Department of Commerce, National Oceanic and Atmospheric Administration's Office of Coastal Zone Management (CZM) has a planning and review role in the coastal zone. Under the Coastal Zone Management Act, the CZM has the responsibility to preserve, protect, develop, and, where possible, restore and enhance the resources of the coastal zone. The CZM grants money to States under CZM plans and has the responsibility for approving those plans.

The USFWS manages public use of three National Wildlife Refuges-- Egmont Key, Passage Key, and Pinellas (six mangrove islands, including Tarpon Key, in Boca Ciega Bay)--within Tampa Bay.

4.2.2 State Involvement

Most of the regulatory and permitting authority within jurisdictional waters of the State is held by the Florida Department of Environmental Regulation (FDER), although Florida Department of Natural Resources (FDNR) approval is required on many permits. Chapters 253 and 403, Florida Statutes, with further definition in the Florida Administrative Code Rules 17-3, 17-4, and 17-12, are the basis of the jurisdiction and regulatory functions of the FDER.

As part of the permit processing, the FDER solicits comments from affected parties and local governments. Comments are also received from either the Florida Game and Freshwater Fish Commission or the FDNR concerning the effects of the project on fish and wildlife habitat and endangered or threatened species (as authorized by the Florida Endangered and Threatened Species Act of 1972).

The role of the FDNR in this process is to administer and enforce regulations for use of submerged and tidal land belonging to the State as authorized in Chapter 253, Florida Statutes, with administrative procedures in Florida Administrative Code Rule 160-17. The FDNR comments on the use of State-owned submerged lands, but the title and administrative control is still held by the Board of Trustees of the Internal Improvement Trust Fund--currently represented by the Governor and Cabinet. Use of State-owned submerged land is typically not granted if the comments are unfavorable.

As part of the responsibility for the regulation and management of fish and wildlife habitat in marine and estuarine waters, FDNR manages the four aquatic preserves in Tampa Bay--Cockroach Bay Aquatic Preserve, Pinellas County Aquatic Preserve, Boca Ciega Bay Aquatic Preserve, and Terra Ceia Aquatic Preserve (Figure 104). Aquatic preserve designation limits the extent of dredging, filling, and construction in the preserve in accordance with Section 258.42, Florida Statutes. Basically, beyond "reasonable ingress or egress by riparian owners," only projects in the "public interest" can occur within an aquatic preserve. The FDNR is also responsible for acquisition of lands for preservation as wildlife habitat and recreational areas. An example is the Bower Tract, a 627-ha tract in northern Old Tampa Bay, which has been purchased as a State Conservation and Recreation Land Program (CARL) acquisition by the FDNR.

Both the FDER and FDNR are responsible for protection of water quality. The FDNR has limited responsibility for direct discharges; the FDER, through broad regulatory and enforcement powers, has a greater permitting and enforcement responsibility to protect and improve water quality. Both the FDER and the Southwest Florida Water Management District (SWFWMD) regulate the flow of surface water into Tampa Bay. Surface water runoff is managed and permitted by both organizations and the SWFWMD controls ground water levels by controlled discharges from upland canals. The SWFWMD also permits construction within and uses of the waters of the canal system within their district.

The Florida Department of Community Affairs (FDCA) has a planning role concerning the regional impact of development and designating areas of critical concern.

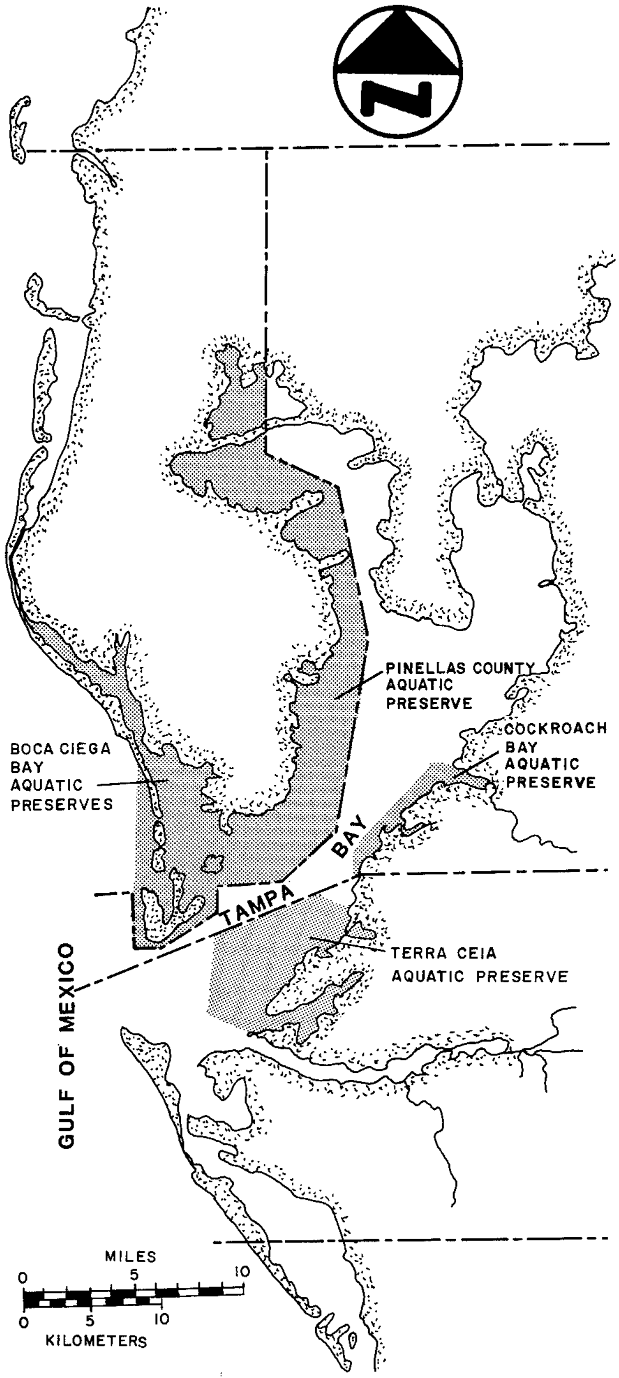


Figure 104. State designated aquatic preserves located in Tampa Bay (adapted from TBRPC 1983).

4.2.3 Local Involvement

The Tampa Port Authority (TPA) has permitting authority and jurisdiction pursuant to Chapter 84-447, Florida Statutes, Special Acts of 1984. Jurisdictional waters include all tidal waters of Hillsborough County, Lake Thonotosassa, Lake Keystone, the Alafia River, the Hillsborough River, and the Little Manatee River. Their review of the projects includes assessments of the engineering, hydrographic, and biological aspects by the TPA Environmental Affairs Department.

Most local government organizations in the Tampa Bay area have the opportunity to review and comment on applications during the State and Federal permitting process. The Tampa Bay Regional Planning Council (TBRPC) and county governments surrounding Tampa Bay (Hillsborough, Pinellas, and Manatee) comment on the permissibility of applications to the Federal, State, and local permitting agencies according to their local regulations. Hillsborough County receives money from the TPA permit fees to pay for review of applications by the County Environmental Protection Commission and Planning Commission.

The TBRPC has the lead planning role in Tampa Bay. It established the Tampa Bay Management Study Committee in 1982 to identify critical bay problems and to evaluate potential solutions which were published in the Management Study (TBRPC 1983). In 1984, the Tampa Bay Management Study Commission was created. It had five subcommittees--ecological, industrial, institutional, economic, and recreational--and was comprised of representatives from local, regional, State, and Federal agencies, the academic community, and other interested persons and organizations. In 1985 the Future of Tampa Bay (TBRPC 1985) recommended the formation of the Agency on Bay Management. The agency is composed of 40 members from the same cross section as represented in the Tampa Bay Management Study Commission and is to perform a coordination and advisory function for actions affecting Tampa Bay.

Most of the municipal governments surrounding Tampa Bay require construction permits for structures constructed in the coastal zone of Tampa Bay. This permit process typically does not include an environmental assessment, and the municipal governments do not have staff to review Federal and State applications.

The FDER has delegated some responsibilities for water quality programs to the county agencies, and most of the local governments have developed ordinances or policies aimed at controlling the impact of development on water quality. Manatee and Hillsborough Counties have conducted routine monitoring studies within Tampa Bay and its tributaries.

Local governments have a limited role or jurisdiction over habitat management. At this level the emphasis has been on county-managed parks including: Upper Tampa Bay Park (Hillsborough County); E. G. Simmons Park (Hillsborough County); and Fort Desoto Park (Pinellas County).

In summary, environmental regulations and permitting authorities exist at the Federal, State, and local levels in the Tampa Bay area. These authorities permit or deny a project in accordance with their individual regulations. Each individual permit must be obtained before a project can proceed. There is no overall plan to create consistency between agencies in the issuing of permits, nor are the overall cumulative effects of several projects considered when issuing permits for each individual permit.

4.3 ROLE OF MITIGATION

4.3.1 Definitions

Mitigation is a legal concept that has been used in a variety of contexts. Its use in projects related to fish and wildlife resources, however, is very recent. The Fish and Wildlife Coordination Act (FWCA) of 1934, as amended in 1946 and 1958, requires that fish and wildlife conservation be given equal consideration with other features in Federal sponsored waterway projects. The USFWS was given the authority to propose and coordinate measures to mitigate damage to fish and wildlife resources.

As discussed in Section 3.2 and Chapter 1, the USACE has been given the authority to regulate construction activities within all waters the Congress regulates under the Commerce Clause. Regulation is in the form of a permitting process. The FWCA and National Environmental Policy Act (NEPA) authorize the USACE to deny, on environmental grounds, applications involving Federal monies (Power 1973). In accordance with a 1985 Memorandum of Agreement, the USACE agreed to consult and consider the recommendations of the USFWS on environmental matters before issuance of a permit. In fact, the USACE routinely circulates all applications to other Federal, regional, State, local, or private organizations having jurisdiction over, or interest in, a proposed project. The USFWS and other agencies review and provide recommendations on the project. The USACE is required to consider the recommendations of USFWS and others in the decision-making process, but the USACE has the final decision.

The USACE frequently takes no action on a permit application until differences are resolved between the applicant and the USFWS. This approach requires that active negotiation concerning fish and wildlife habitat occur between the applicant and USFWS. To provide guidance on mitigation policy, the USFWS developed the USFWS mitigation policy which was published in the 23 January 1981 Federal Register.

In development of that policy, the USFWS supported and adopted the definition of mitigation formulated by the President's Council on Environmental Quality in the implementing regulations of the NEPA:

1) avoiding the impact altogether by not taking a certain action or parts of an action;
2) minimizing impacts by limiting the degree or magnitude of action and its implementation;
3) rectifying the impact by repairing, rehabilitating, or restoring the affected environment;

4) reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and
5) compensating for the impact by replacing or providing substitute resources or environments (USFWS 1981a).

It is important to remember that the order in which these actions are listed indicates the priority of their implementation, i.e., avoidance is preferred to minimizing impacts, etc. Compensation should be used only after all other alternatives have been exhausted.

The general statement of the policy is that the USFWS will "seek to mitigate losses of fish, wildlife, their habitats, and uses thereof from land and water developments." This will be done by "early involvement in land and water development planning activities in advance of proposals for specific projects or during the early planning and design stage for specific projects" (USFWS 1981a).

When mitigation for unavoidable impacts must be considered, the minimum requirements the development project should meet are:

Public need - There should be a demonstrated public need for the project, and its expected benefit to the public interest should outweigh foreseeable detrimental impacts on fish and wildlife resources.

Water dependency - The proposed activity should require access or proximity to or siting in the aquatic environment.

Unavoidable impacts - Use of mitigation should be allowed only after all other alternatives of impact avoidance and minimization have been exhausted.

Recognizing that not all resources are of equivalent value, the USFWS designated four Resource Categories, each with a specific mitigation goal (Table 39). Resource Category designations are to be made early in the mitigation planning process in coordination with other Federal, State, and local agencies. The determination of the Resource Category for a given habitat is based upon the designation criteria. The designation criteria are based on the value of habitat for species designated by the involved agencies, and its rarity and importance on a national and ecoregional level. Resource Categories 1 and 2 are for habitats that are of high value and irreplaceable or scarce on a national or regional level. The mitigation goals for these categories are to allow no loss of habitat value for Resource Category 1 and no net loss of in-kind habitat value for Resource Category 2. Important Resource Problem areas (IRP), as defined by the various USFWS regions, may be given special consideration and include such areas as floodplains, wetlands, mudflats, vegetated shallows, and coral reefs. Other types of areas given special protection are wildlife management areas, hatcheries, and refuges.

Actions that avoid, minimize, or reduce the adverse impacts of a development usually occur in the planning stages of a project or are the product of an alternative plan. These actions alone may mitigate for the adverse effect. However, because these types of mitigation occur within the development plan, they are usually not specifically identified as mitigation. Therefore, mitigation as most commonly used, has come to mean compensation for an unavoidable loss of habitat with the requirement that the same habitat by recreated elsewhere. Less commonly, mitigation is applied as rectification or the repair of the affected habitat. This application is usually found in after-the-fact court orders to restore an illegally destroyed habitat. When compensation is the form of mitigation being discussed, we will call it compensation.

As used by USFWS, mitigation is used to prevent the loss of fish and wildlife habitat values. Because this study is concerned with wetlands, we will limit our discussion to mitigation for wetland habitat. Other functions of wetlands such as erosion control, improvement of water quality, and flood control may be also

Table 39. USFWS Resource Categories, designation criteria, and mitigation goals (from USFWS 1981a).

Resource category	Habitat designation criteria[a]	Mitigation goal
1	High value for evaluation species and unique and irreplaceable	No loss of existing habitat value
2	High value for evaluation species and scarce or becoming scarce	No net loss of in-kind habitat value
3	High to medium value for evaluation species and abundant	No net loss of habitat value while minimizing loss of in-kind habitat value
4	Medium to low value for evaluation species	Minimize loss of habitat value

[a]Based on selected species used to characterize the habitat.

given consideration in the development of a mitigation plan. The provision of these additional functions provides additional improvements to the system, also providing habitat for fish and wildlife.

Individual State policies on mitigation are extremely variable. Most apply mitigation only as compensation for habitat lost, leaving the other forms recognized by USFWS to the planning area. Only California and Oregon have established clear mitigation requirements during the development of their Federally-approved coastal management plans. Florida currently has no mitigation policy, but may decide to consider mitigation through permit conditions after evaluating the following factors (FDER 1983):

"1) whether or not the area to be impacted is a highly productive aquatic system;

2) whether or not the proposed mitigation will compensate for the wetland functions to be destroyed; and

3) whether or not the project has been determined to have an overriding public interest benefit."

As discussed in Section 4.2, statutory authority to regulate construction activity below mean high water and in adjacent wetlands of parts or all of Tampa Bay has been given to the USACE, FDER, and TPA. Any of these authorities will consider mitigation proposed or added at any time during the permitting process. The mitigation may be proposed by the applicant or requested by the USACE, FDER, TPA, or another Federal, State, regional, or local agency.

4.3.2 Information Needs for Mitigation of Unavoidable Losses

The objective of the mitigation process for USFWS should be to maintain the functional and productive capacity of the fish and wildlife resources of the nation or area, while accommodating necessary economic activity that is

clearly in the public interest. Coordination and planning for this process are best accomplished at a regional level. If after all conditions on the need of the project have been met and all alternatives exhausted, the project is approved, mitigation in the form of compensation is necessary. The questions that need to be answered in developing a mitigation plan compensating for unavoidable losses are:

1. What to restore?
2. Where to restore?
3. How to restore?
4. How much to restore?

The development of regional restoration goals based on the types of habitat needing replacement will be useful to determine what and where to restore. Possible goals for determining which habitats are important are:

1. replace what was lost, in-kind replacement of important habitats;
2. provide habitat for target species, in-kind or out-of-kind replacement; or
3. increase diversity of habitat, in-kind and out-of-kind replacement.

In-kind replacement has been and is the recommended method for compensation because this type of mitigation is used to replace habitats recognized as important and in short supply. In the past, on-site compensation or compensation adjacent to or in the immediate vicinity of the development site was recommended. It was assumed that because the same species exist or existed on-site, the probability of the habitat recovering was high. This is still the preferred type of compensation, provided the restored area is not isolated and is large enough to provide useful habitat. However, off-site compensation or compensation occurring away from the development site but within the same ecological system is recognized as acceptable, especially when it provides for the preservation and restoration of large sites. These are also often more economical to restore as well. Out-of-kind compensation may be recommended to provide for a rarer habitat or resource or as part of a larger project where increased habitat diversity is feasible.

Once regional goals are set, design criteria for each habitat identified in the regional goals can be developed. Design criteria will be useful to answer the question of how to restore. Design criteria are the specific habitat requirements, prey requirements, and the timing of use of the habitat for all important or desirable species of the region. The desirable species should include members of all trophic levels from plants to higher predators. Using the regional goals and the design criteria, groups of species with requirements that are compatible with each other can be chosen for various environmental conditions imposed by the characteristics of the site where mitigation is to occur. A plan for the site can then be developed. This plan should provide enough specifics about the habitat characteristics, e.g., vegetative types, elevation, water dynamics, sediments, animal use, that defining measures of successful completion are possible. The success of these design criteria to meet the regional goals and the goals for each project can then be assessed and revised as necessary. When the design criteria fail to result in use by the designed species, the reasons can be determined and the criteria changed. When the design criteria are not known, experimental field research to determine these is necessary. The reports by Josselyn and Buchholz (1984) and Zedler (1984) provide further details about this approach.

It is not desirable to have an experiment serve as compensation since it is unlikely that all the treatments tested will prove successful. However, the information needed for future restoration projects and the documentation to identify the conditions for successful restorations is available when an experimental protocol is used. These types of studies should be encouraged and supported by the agencies involved in restoration of wetlands.

An effective mitigation program requires that the regulatory and commenting agencies have a means of evaluating the losses and gains of a development project and proposed

compensation. This answers the question of how much to restore. Many previous projects have not been adequately evaluated. Consequently, conflicting claims of impacts and mitigation requirements have been difficult to resolve. Lengthy disputes have resulted, in which project opponents often appear as unreasonably obstructive. In such cases, final settlements typically result in losses of fish and wildlife habitat as described in Chapter 1.

The USFWS formulated its mitigation policy and Habitat Evaluation Procedures (HEP) (USFWS 1981b) to eliminate many sources of dispute by providing an objective system of analysis previously agreed upon by principal interested parties--the project sponsor, at least one key State resource agency and one key Federal resource agency, each represented on the evaluation team. This procedure attempts to identify and resolve most conflicts during the evaluation rather than much later during the review process. The HEP analysis consists of the selection of a set of species to represent key features of the project area. Documented relationships between habitat quality and environmental variables are then used to determine a habitat suitability index (HSI) scaled from 0.0 for unsuitable to 1.0 for optimal. The product of HSI and the area of available habitat in the project area then provides a measure of the capability of the project area to support each of the evaluation species. The compensation requirement is the difference in the product computed for existing and future conditions without, and existing and future conditions with the project. Alternative project plans and plans to compensate for project losses are evaluated by comparisons between the products of HSI and area as projected for the different options. Models exist for some species found in the habitats in Tampa Bay. Although the applications of these procedures in estuarine environments have been few, with the increasing numbers of models available, their use should become more common. The ability of these models to equalize the losses and gains has not been tested, and only by monitoring how well the predicted conditions meet the actual restored conditions can the models be adjusted to ensure protection of the habitat and biological resources. The large amount of time to achieve functional ecosystems (e.g., mangrove forests), as well as cumulative impacts on these resources, also needs to be considered when evaluating the amount of habitat necessary to compensate for habitat losses. This can be accomplished by assuming that the HSI for future conditions involving restoration will always be less than 1.0.

Compensation projects should be monitored periodically to assure that the goals of the project are being met. For most projects, yearly monitoring until the goals of the project have been successfully achieved is sufficient. The goals, of course, need to be decided upon before the project is undertaken and the parameters to be evaluated during monitoring would be determined by the projected goals. Typically, the parameters sampled would be vegetation (cover, height, and biomass), animal use (diversity, numbers, age structure, and biomass), sediment characteristics, and soil elevation. Comparisons of functions with natural marshes in the area would be useful if comparable natural marshes exist.

4.3.3 Past Types of Mitigation Projects

Ashe (1980, 1982) has classified previously attempted estuarine mitigation projects requiring compensation for unavoidable adverse impacts in the United States into those involving:

1) increased public access;
2) acquisition;
3) single-purpose mitigation;
4) indemnification or "in-lieu" payments;
5) acquisition and management; and
6) restoration of previously altered resources.

Although increased public access to the resource has been a priority with area-wide project planners, it is not acceptable as compensation unless mitigating for recreational losses such as loss of a fishing area. This category serves to subsidize only economic and social objectives at the expense of

increasingly scarce and valuable wildlife resources (Ashe 1982).

The acquisition and subsequent preservation of an area to compensate for the loss of another area has been used as a form of compensation. Acquisition alone is not usually considered as an adequate form of compensation. Acquisition may provide mitigation credit if the habitat is vulnerable for development and is considered an important resource by the USFWS. An example is the acquisition of bottomland hardwood communities in the lower Mississippi Valley. This type of compensation alone is usually not acceptable for coastal wetlands where greater regulatory controls on development exist. In most cases in Florida, the applicant relinquishes the ownership of wetlands to utilize a portion of wetlands or a wetlands transitional area. The area becomes a "conservation easement" filed with the county tax assessor. For a nominal fee, the conservation easement is transmitted to and held by a responsible environmental agency or society, e.g., FDER, Nature Conservancy, Audubon Society, etc. Acquisition alone results in a net loss of wetland habitat when it is proposed as mitigation to offset the loss of habitat.

Single-purpose-mitigation is probably the most common type of mitigation requiring compensation. It may involve the creation or restoration of a key habitat (e.g., salt marsh, mangrove, seagrass) or a habitat for a key species or group of species. This type of compensation is acceptable though there needs to be more information about the goals and purposes of the restoration. The setting of regional goals and design criteria would assist in providing this information. The success of habitat restoration within Tampa Bay and South Florida was evaluated in Chapters 1 and 2. If the area to be restored is sufficiently large to provide a variety of functional habitats, a mosaic of habitats, as recommended in Chapters 1 and 2, may be suitable as compensation.

Although this type of compensation has been used for creation of habitat for endangered species, this is not allowable under the provisions of the USFWS policy on mitigation. The Endangered Species Act prohibits the destruction or adverse modification of habitat critical to these species. The creation of small new habitat areas is usually an inadequate and simplistic solution to the general problem of unavailability or loss of habitat for these species.

Indemnification, or "in lieu" payments, involves the placement of monetary value on ecological resources and the exchange of money for the destruction of that resource. The payment is made to a public agency which may use the funds to somehow rebuild or replace the loss of the resource. This method of compensation has been used extensively in the past for after-the-fact assessment of fines in enforcement cases. An example was the donation of $50,000 to the Biscayne Bay Restoration and Enhancement Program [managed by Dade County Environment Resources Management (DERM)] by Quayside, a condominium development in north Biscayne Bay, to dredge for marina development. The money, in this case, did not replace the habitat lost during marina construction. As mitigation requiring compensation becomes more common, this after-the-fact assessment type of mitigation will not be acceptable.

Simple acquisition, as previously described, should not be considered by regulatory and/or planning agencies to be a viable form of compensation, but acquisition in conjunction with active management of fish and wildlife habitat within the system has been a successful means of offsetting project impacts. However, critics argue that the management component of this compensation method has been consistently inadequate and difficult to enforce over a long period of time (Farmer 1979; Ashe 1982; R. Walesky, FDER, pers. comm.). Although management may improve the habitat value of an area, this type of compensation may result in a net loss of habitat acreage for a select cover type.

The use of acquisition and management as a compensation scheme depends upon: (1) the availability of manageable habitat, preferably in private ownership by the applicant; (2) the development by the concerned agencies and applicant of an

effective management program which the applicant is willing to implement; and (3) the ability to monitor implementation of the management program.

The enhancement of previously altered systems was also evaluated in both Chapters 1 and 2. The removal of spoil mounds within wetlands, restoration of tidal flow to isolated wetlands, and planting wetlands species within regraded areas were methods attempted with variable success. This method of mitigation was recommended as a means of immediately restoring wetlands function to an area and may be used to rectify for adverse impacts of development.

Mitigation banking is a relatively new concept which has the advantages of providing an economical method of restoration for unavailable losses while ensuring that the restoration objectives are successful before the loss of wetlands to development. As defined in the USFWS mitigation policy (USFWS 1981a), mitigation banking means habitat protection or improvement actions taken expressly to compensate for unavoidable losses from specific future development actions. In simplified terms, a mitigation bank is similar to a bank account in that a wetland habitat is created to be the bank from which habitat credits are drawn. The measures to create, restore, enhance, or preserve fish and wildlife habitat are done by the developer or bank sponsor and regulatory or planning agency in advance of future unavoidable losses from anticipated or planned projects. Projects requiring mitigation for unavoidable losses and for which on-site mitigation is neither desirable nor feasible, may draw upon the mitigation bank for their projects.

The banking procedure requires a means to quantify the impacts of the construction and the benefits from the restoration measures. The resultant credits and debits form the mitigation bank account. The bank is managed by the appropriate environmental management and/or planning agency.

The bank sponsor may sell habitat credits to others requiring compensation in the region, provided their project meets the necessary criteria to use the bank. Habitat unit values (e.g., Habitat Evaluation Procedure) is the methodology for evaluating credits and losses. This scheme may be considered for an area-wide mitigation bank managed by a central authority responsible for evaluating the losses and initiating the creation, restoration, and enhancement efforts with the money provided.

The mitigation banking concept is useful for organizations that can plan for development several years in advance, provide for advance funds to set up the mitigation bank, have reasonable assurance of obtaining the necessary permits for development, and have the ability to acquire and provide for the restoration and management of property. Port authorities, transportation departments, and other organizations performing functions in the public interest and requiring periodic expansion are examples of where there may be the potential for use of a mitigation bank.

The Tenneco LaTerre (TLT) Corporation established a mitigation bank in a wetlands area of coastal Louisiana to mitigate for unavoidable impacts to fish and wildlife resources resulting from oil and gas development in the marshes of Louisiana. The bank provided for management of coastal marshes owned by TLT. Wetland loss in Louisiana has been high, in part caused by canalization for oil and gas development (Johnson and Gosselink 1982; Turner et al. 1982). The management plan would increase freshwater and sediment inflow to maintain the growth and health of the freshwater marshes and reduce saltwater intrusion. The TLT established a 25-year management program in 2,024 ha of coastal marsh in Louisiana. The USFWS, using the Habitat Evaluation Procedures, calculated the average annual habitat units gained by the management program. It was estimated that the established mitigation bank would be capable of offsetting the damages of approximately 60-120 "typical" oil and gas exploration canals (Soileau 1984; Zagata 1985).

The Port of Los Angeles and the Port of Long Beach developed mitigation banks in 1984. The banks were created through a

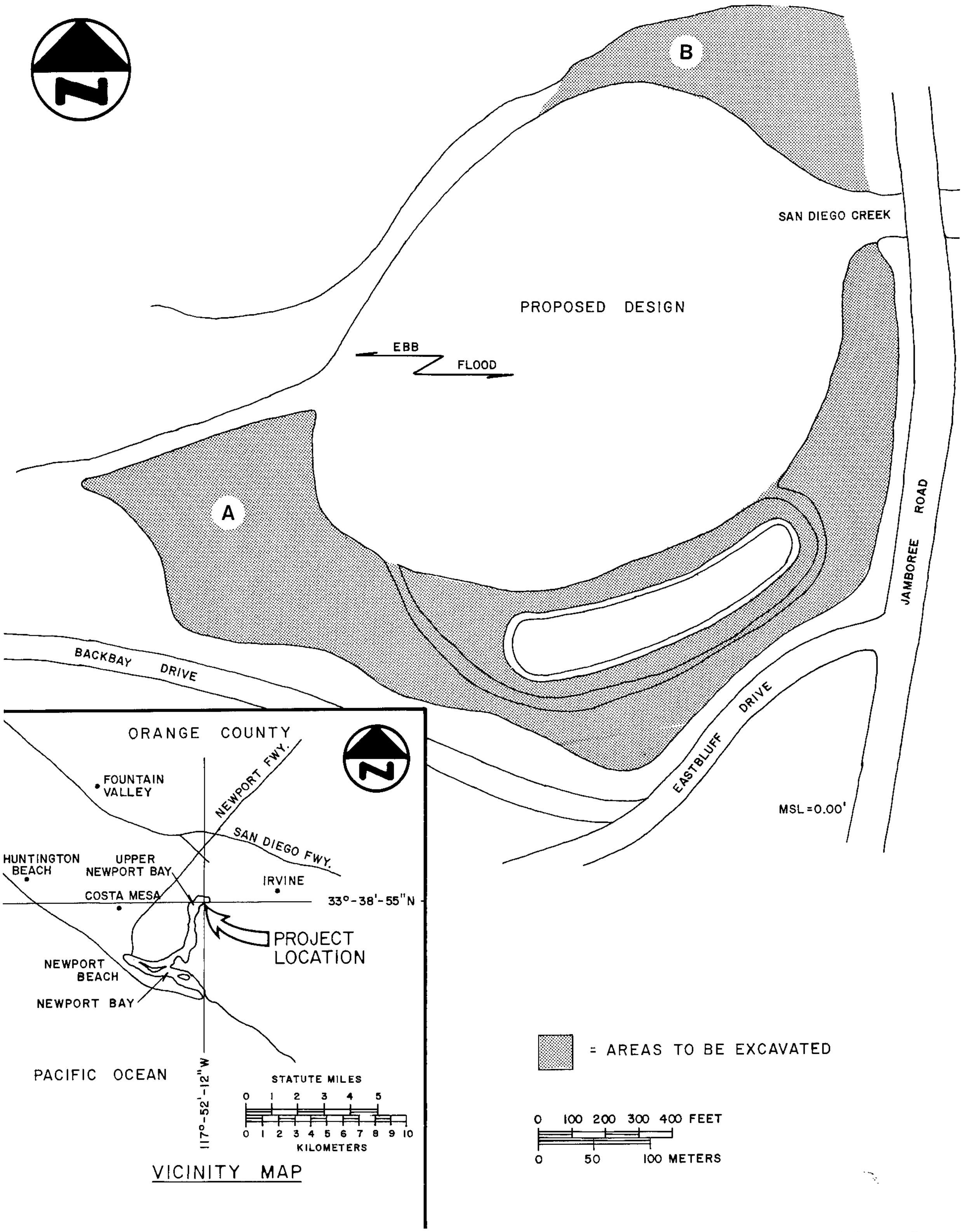


Figure 105. Marine environment mitigation in Upper Newport Bay for Port of Long Beach expansion (from Board of Harbor Commissioners of the City of Long Beach, CDFG, NMFS et al. 1984).

Memorandum of Understanding (MOU) entered into by Federal, State, and local governments. The purpose of creating the banks was to allow development of the ports while assuring that the mandates of the USFWS and the NMFS were fulfilled.

The MOU (Harbor Department of the City of Los Angeles et al. 1984) agreed upon for the Port of Los Angeles was created to offset submerged bottom losses resulting from fill within the port. Simply stated, the agreement was that creation of new submerged bottom by excavation of upland offsets losses of submerged bottom resulting from filling of submerged bottom land. The habitat value of the submerged bottom area created to that loss was considered equal if the water depths were equal. The port created a net habitat gain and loss accounting which included a summary of habitat gains and losses from projects undertaken within the port boundary since the inception of the Federal permitting program. As a result, the port has begun the MOU with a credit of +7.2 ha of area. The MOU is valid until the balance of the created habitat value is consumed.

Project details were not available for this review, but it appears most of the habitat credit derives from creation of a channel and marina complex, whereas losses involved filling of submerged acreage of undefined depth.

The MOU agreed upon for the Port of Long Beach (Figure 105) was created by the port in anticipation of harbor developments that would result in approximately 16 ha of submerged land being filled.

The bank was created within the 300-ha Upper Newport Bay Ecological Reserve located in Orange County and managed by the California Department of Fish and Game. The reserve site in Newport Bay was considered the most feasible restorable site and the agencies considered coastal wetlands restoration as a desirable mitigation measure, because 75% of these habitats have been lost in southern California. The plan called for the port to restore tidal influence to "a predominantly barren area above the reach of the tides, presently [providing] minimal habitat value" (Harbor Commissioners of the City of Long Beach et al. 1984) (Figure 105).

Relative habitat values for the areas lost (filled) and gained (restored) were formulated by using a modified HEP because of the absence of species models for appropriate marine and estuarine species, and the unavailability of (USFWS) HEP trained personnel (Board of Harbor Commissioners of the City of Long Beach et al. 1984). Bird and fish sampling data--including shared species, common biological functions, productivity values, fish nursery value, ecosystem physiography and areal extent for both areas considered--were summarized and analyzed in planning aid reports prepared by the USFWS.

General recommendations for development of a mitigation bank by the TPA can be drawn from the banks developed for the Ports of Los Angeles and Long Beach. The type of bank developed for the Port of Los Angeles would not result in an improvement of wetlands habitat. The need to reverse the trend of habitat loss in Tampa Bay is well documented (TBRPC 1985); therefore, to consider past port development actions as any form of mitigation for credits for future projects would not improve this trend.

The mitigation bank approved for the City of Long Beach more closely approaches the type of bank required in Tampa Bay to reverse the trend toward habitat loss. The mitigation action in Long Beach, however, represents enhancement of an existing but degraded wetlands area. In Chapter 2, enhancement of existing wetlands was considered an unacceptable alternative to mitigate direct wetlands losses occurring during development.

As can be seen from this discussion, the approaches to mitigation have taken a variety of forms. Mitigation to avoid, minimize, rectify and reduce the effects of adverse impacts has not been assessed. The evidence on mitigation projects to compensate for unavoidable impacts developed in Chapters 1 and 2 suggests that past efforts have resulted in a net loss of habitat. Approaches that do not increase the area of wetland or result in

a measurable improvement of habitat quality should not be acceptable as mitigation for the loss of wetland habitat.

When there are necessary unavoidable losses of habitat, the goals of the mitigation effort should be clearly defined and the design criteria to achieve those goals should be stated. The results should be monitored to determine that the design criteria achieve the regional goals and result in a functioning wetland.

4.4 CURRENT STATUS OF MITIGATION IN TAMPA BAY

Chapter 1 reviewed mitigation projects requiring compensation subsequent to and during the formulation of Federal and State environmental regulations. Since 1972, when much of the environmental legislation was effected, the rate of destruction of coastal wetlands and seagrass habitats has decreased significantly. Nevertheless, an estimated 44% of the original 10,118 ha of mangroves and salt marshes and 81% of the original 30,960 ha of seagrasses have disappeared from Tampa Bay over the last 100 years (TBRPC 1985). If loss of the remaining wetlands acreage is to be avoided, steps must be taken to halt or reverse the ongoing habitat destruction. Development in the coastal zone will not stop. Well thought out environmental laws will help prevent major wetlands losses, but more than environmental issues are considered during project planning and permitting. Particularly in the case of projects in the public interest (e.g., port development and roadway construction), the various agencies must work together to develop the best alternative for the biological habitats and public needs. Development of the best alternative is aided by definitive policies developed by the agencies.

The Federal government has developed a policy on the development and use of mitigation during project planning and permitting; the State, however, has not. The previous discussion on the role of mitigation in the management of Tampa Bay demonstrates that Federal government has been advancing in the ability of the USFWS to comment on the acceptance of mitigation during the USACE permitting process. The USFWS is able to participate in mitigation banks to further expedite the process and gain adequate assurances that environmental damages are considered in the planning process for development activities. However, mitigation banks are currently approved only after review at the national level. USFWS has used the Habitat Evaluation Procedures to evaluate habitat gains and losses for a development project.

The State of Florida has approached the use of mitigation cautiously. The Warren S. Henderson Wetlands Protection Act of 1984 gave FDER the authority to consider mitigation. The State has not developed a policy on how mitigation will be defined or how or when to consider mitigation. As currently used in Florida, mitigation is only considered when compensation for unavoidable losses is required. This has resulted in a lack of consistency between projects and between State and Federal decisions on mitigation as evidenced by the TPA in 1982 to develop berths at Hooker's Point (USACE, File No. 82L-1040; FDER, File No. 290588389).

The mitigation plan developed for this project (Mangrove Systems, Inc. 1981) proposed to create 8.2 ha of wetlands at Delaney Creek for the loss of 10.8 ha of wetlands. The USFWS (Carroll 1982) evaluated the project and the proposed mitigation action and recommended that the compensation be increased to include the creation of 2.8 ha of shallow-water habitat. No evident evaluation procedures, however, were presented in the letter form recommendation. The FDER assessed the project (FDER 1982) as requiring the dredging and filling of approximately 40 ha of productive shallow marine habitat. Also, the FDER asserted that the dredging of the slips to -6 or -9 m MLW would cause violations of the State water quality standard [17-3.121(14), Florida Administrative Code] near the bottom and could also cause algal blooms and fish kills.

The FDER did not evaluate proposed wetlands to be created at Delaney Creek stating that "the project cannot be justified by a mitigation plan" (FDER 1982). An "Intent to Deny" was issued by

the FDER, and the TPA withdrew the project (W. K. Fehring, TPA; pers. comm.). Because of the development of the policy on mitigation by the USFWS, the USACE permit was obtainable after proposing the recommended additional creation of 2.8 ha of shallow-water habitat. The policy of the FDER at that time was that a project must be permissible before mitigation could be considered. As identified in Section 4.4, the FDER in 1983 began to consider mitigation in specific situations; the general policy, however, has to date not changed. Development by the FDER of a system of evaluating the potential losses and gains from the proposed project and mitigation must occur.

The mitigation site proposed for the Hooker's Point project (Delaney Creek pop-off canal) was evaluated in Chapter 3 as a potential mitigation site. Single mitigation sites large enough in size to compensate for large dredge-and-fill projects such as proposed at Hooker's Point were found to be scarce within Tampa Bay.

Evaluation of trends of wetland losses in Tampa Bay (CSA 1983; K. Haddad, FDER; per. comm.) has shown that the greatest losses have occurred in Hillsborough Bay. To prevent any further losses of habitat within any region of Tampa Bay, particularly Hillsborough Bay, regionalization of restoration projects may be desirable to replace habitat where losses have been greatest. The ownership of the submerged lands within Hillsborough Bay by TPA should be an asset in development of a restoration program in that region.

To develop a mitigation plan for the TPA, the steps that should be taken include: 1) chronological projection of future dredge-and-fill needs, anticipated unavoidable habitat losses, and environmental impacts for the next 25 years; 2) identification of particular aspects of future projects which can be mitigated by modifying or rectifying the project designs to avoid, reduce, minimize, or rectify adverse impacts; 3) chronological projection and development of a dredged material management plan for construction and maintenance of dredged material; 4) establishment of an interagency team with TPA, the State of Florida, and USFWS to evaluate and implement a habitat evaluation program for the estuarine and marine habitats/species expected to be affected in Tampa Bay; and 5) incorporation of all the above steps into conceptual mitigation plans or bank which can then be evaluated and developed within the guidelines of the pertinent regulatory agencies. Sites that would not be feasible for implementation by the TPA or included in a conceptual mitigation plan could be authorized and implemented as a function of the Agency on Bay Management under the TPRPC. Project sites in Old Tampa Bay could also be used by FDOT in the development of a mitigation plan for bridge-causeway expansion.

4.5 RECOMMENDATIONS

As the legal framework for environmental preservation and protection becomes more defined on all levels of government, the fact that we can no longer afford to lose wetland habitat to development should be made clear. To achieve this goal, mitigation that avoids, minimizes, and reduces the effects of development on wetlands should be recommended before replacement of habitat is even considered. There is a need for a local agency with an ecoregional perspective to oversee and coordinate the protection of natural resources in Tampa Bay.

The initial steps in a coordinated effort to set regional goals for correction of the environmental problems in Tampa Bay have recently been undertaken by the Tampa Bay Management Study Commission (TBRPC 1985). The Future of Tampa Bay (TBRPC 1985) proposes solutions and funding sources for many of the environmental problems indentified in Tampa Bay.

When a project has been found to meet the requirements justifying unavoidable loss of habitat and all other alternatives have been explored, mitigation requiring compensation may be necessary. To provide guidance to developers and agencies for developing an acceptable compensation plan, the local agency should have defined

regional restoration goals and determined the design criteria adequate to achieve these. The regional goals will determine whether in-kind or out-of-kind habitat replacement is to be recommended. Information from the Geographic Information Study of Tampa Bay (National Coastal Ecosystems Team in prep.) on trends of wetland change will be useful in setting regional goals. The feasibility of different types of restoration should also be considered.

In this report it has been shown (see Chapters 1 and 2) that marsh vegetation, i.e., mangroves and *Spartina alterniflora*, can be planted with relative ease and expected to grow well in Tampa Bay. As demonstrated in Chapter 2, seagrass restoration, however, is still experimental and results are unpredictable. The value of benthic habitats and recommendations for their restoration has not been determined.

For compensation to be fair and consistent, standardized evaluation procedures (ways to determine the gains and losses from a development project and compensation plan) need to be used. The USFWS Habitat Evaluation Procedure (HEP) is useful, although it has not been used extensively in coastal environments. The reasons appear to be the limited availability of trained personnel, the uncertainty about its validity in habitats that are naturally variable, and the limited availability of models. However, the number of models for species in wetland habitats have recently increased. HEP also does not evaluate all wetland "functions." Adamus and Stockwell (1983) have proposed procedures reported to evaluate other "functions," but some of the assumptions used to develop the predictors are untested, disputable, or wrong for some regions of the country. Before this or any procedure is recommended for use, it needs extensive field testing by qualified scientists in the types of wetlands for which it is recommended. These tests should be performed in wetlands for which there are at least 5 years of hydrological and ecological data and the procedures revised to reflect what is learned.

Once compensation has been accepted, compliance with the plan proposed must be ensured. This is best accomplished by including a consistent monitoring plan as part of the project cost. The information provided by monitoring can also assure that regional needs are being met, provide information for updating regional goals and more effective design criteria, and indicate where research is needed.

More research is needed on certain aspects of wetland restoration. Seagrass restoration is still experimental and results are not predictable. More research is needed on the animal use of mangrove and *Spartina alterniflora* restoration projects, comparing them with existing stands of the plants. Much of our knowledge on these systems is intuitive and, as Nixon (1980) indicates, many of the assertions may be generalizations. This research may lead to more effective design criteria for the planning and monitoring of restoration projects.

A major problem in implementing any type of mitigation policy for Tampa Bay is that the State has only begun to create the necessary legislative framework. The Wetlands Act of 1984 provides for mitigation of activities deemed unavoidable, i.e., compensation in the USFWS policy, due to the public interest in the project. The procedures for administrating this policy, however, have not yet been defined and therefore guidance for the administration of these laws currently does not exist. Therefore, development of State, regional, and local mitigation policy needs to occur and be coordinated with the Federal policy to provide guidelines for wetland protection and development.

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15. Supplementary Notes

16. Abstract (Limit: 200 words)

Ten past restoration projects in Tampa Bay were evaluated. Habitats included *Spartina* marsh, mangrove forests, *Juncus* marsh, and subtidal habitat. Success was difficult to determine because goals for each project had not been defined. In-kind losses of habitat occurred in all but one project. Permanent losses occurred in at least three projects. Restoration of *Spartina* and *Juncus* marshes was recommended. Mangroves will recruit into *Spartina* marshes, provided a seed source is available; planting of mangroves alone is not recommended. Seagrass restoration is not recommended at this time. Twelve sites, most less than 50 ha, were identified as potential restoration sites to give 344 ha of subtidal habitat to be made shallower and 176 ha of uplands to be scraped down. The current management program's legal and policy needs for improving environmental management, the role of mitigation, and the information needed to develop mitigation plans are discussed. This report will be useful to decisionmakers concerned with wetland habitat loss and restoration in Tampa Bay, Florida, and other areas with similar habitats.

17. Document Analysis a. Descriptors

Seagrasses

b. Identifiers/Open-Ended Terms

Tampa Bay Florida	habitat
mangroves	mitigation
marshes	habitat restoration

c. COSATI Field/Group

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